JAN 6 1941

ENGINEERING NEWS-RECORD

JANUARY 2, 1941

Road and Rail Approaches to Baton Rouge Bridge

Divided Road Drainage
A Hill Top Airport
Garbage With Sewage
Construction Housing

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THAT WILL

STAY PUT!

IT'S

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Byers Wrought Iron has been used in so many localities for so many years that there is a large amount of service data available to guide specifiers. For example, a 52-year-old casing was pulled at Rockford, Ill., when the well was enlarged, and found to be in excellent condition. An 8" wrought iron casing gave satisfactory service at Madison, Wisconsin, for 43 years. A large meat packer extended the flow lines of a 10-year-old wrought iron-cased well with three lengths of another material, which failed after only 11 years. Inspection showed the 21-year-old wrought iron to be still in excellent condition. Our Engineering Service Department has numerous other case histories, and will be glad to make recommendations based on them if you have a casing problem. You will also find our General Catalog, which lists Byers Casing, a convenience. Write for a complimentary copy.

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TUBULAR AND FLAT ROLLED PRODUCTS

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ENGINEERING NEWS-RECORD

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Vol. 126 JANUARY 2, 1941 No. 1

THIS WEEK

• A new and complex design problem faces the road engineer in disposing of runoff on divided highways. Varying cross-profiles change the direction and volumes of water shed to edges and centers and require various forms of water-collecting structures. The type of median strip—that is, whether it is to be planted or curbed and paved and whether it is to be raised, depressed or sloped—all enter into the solution of the problem. How is it being solved? Some of the answers appear on page 40.

• Three million yards of earth, shale, and limestone was moved for less than 28c. per yd. in constructing a hilltop airport at Wheeling, W. Va. A 5,200-ft. runway, almost exactly in line with the prevailing wind, and two others 3,200 ft. long, both of which may be extended to 5,000 ft., are provided. The contractor worked under a WPA participating contract. How this slow-cost construction was made possible makes an interesting story on page 32.

THINGS TO COME

• Never before has a year closed with as little knowledge of what is to happen in roadbuilding in the new year as is the case today. Everyone knows that huge sums must be spent on access roads to military camps in the near future, but no one knows when or how much. All the states have been told that federal-aid funds are to be concentrated on the strategic highway network, but Congress has set no policy to be followed. These questions are to be discussed in the Annual Highway Number, January 16.

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Number of copies of this issue printed: 34,929

387 tons of Ryerson New Billet Reinforcing Bars used for Sewerage Treatment Plant at Stevens Point, Wisconsin, by Foster-Morris Co., Milwaukee, Contractors.

Work Progresses "on schedule" with Ryerson Reinforcing

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RYERSON *for* REINFORCING

Nation had biggest construction year in 1940

All sections of country except Middle Atlantic States show large increases as heavy construction awards total nearly four billion dollars

The highest construction volume ever reported in one year by *Engineering News-Record* is $3,987,243,000, the total rolled up in 1940. National defense contracts are chiefly responsible for this speed-up which accounted for two thirds of this volume during the second half of the year.

Both private and public construction contributed to this record. Private work with a gain of 31 per cent over 1939 totaled $1,162,254,000 the highest since 1930. Public construction at $2,824,989,000 set a new all time high with a gain of 34 per cent over 1939, the previous record year.

South has big year

Every section of the country participated in these gains except the Middle Atlantic States. The South turned in a total volume of $853,000,000, the highest on record, and a gain of 88 per cent over 1939. The far West, with $493,000,000, established a new high record for itself by having a gain of 59 per cent over 1939. West of Mississippi states set another all time high with $702,000,000, a 28 per cent gain. The Middle West, with a volume of $743,000,000, has the highest volume since 1929 and a 38 per cent gain over 1939, and New England, with $244,000,000, tops all years since 1930 and shows a 39 per cent gain over 1939. Engineering construction during 1940 in the Middle Atlantic states was $951,000,000, 3 per cent under the 1939 volume.

Industrial building at new high

To the private construction gains, industrial building contributed its highest volume on record, $594,000,000, which is just over the 1929 peak but 110 per cent higher than the volume of 1939. For a full measure of industrial expansion, add to this private industrial building total $300,000,000, which is recorded under "public building" but relates to industrial plants federally-owned to produce armament and ammunition.

Public building doubled

The public building total, expanded by this $300,000,000 for "industrial" structures, plus defense housing for military personnel as well as for civilian defense workers, hit the all time record high of $1,196,000,000. This is a gain of 102 per cent over the previous high in 1939.

Unclassified construction, principally airbases, airports and shipyards, established a new all time high volume record, $603,000,000, a gain of 54 per cent over 1939.

Highways set a new record, without as yet feeling any effects from defense plans, with a total of $678,000,000 or a 5 per cent gain over 1939.

Besides these record breakers, commercial buildings at $400,000,000, gained 3 per cent over 1939, earthwork, irrigation and drainage at $234,000,000, gained 1 per cent, bridges at $120,000,000 dropped back 20 per cent, waterworks construction at $70,000,000 was 57 per cent below 1939, and sewerage at $91,000,000 was 43 per cent below the 1939 figure.

New capital

New capital for construction purposes, $3,894,743,000, exceeded last year's mark by 62 per cent, and reached the highest amount recorded in the last decade. Private investment was 24 per cent above last year; federal appropriations for non-federal work increased 31 per cent over a year ago; and federal appropriations for federal work topped 1939 by 102 per cent.

The year's financing is made up of $1,891,961,000 in federal departmental appropriations; $390,000,000 in WPA funds for construction; $581,918,000 in state and municipal bonds; $390,212,000

Fording in the modern manner

Harry H. Hendon, engineer of Jefferson County, Ala., needed a stream crossing on a secondary road traversing land owned by the Birmingham Water Works Co. A bridge would have cost $50,000, so a ford was built. The crossing consists of a slab about 30 ft. wide and 100 ft. long. At each side of the road short square pillars are used to mark the roadway during high water. The work was done as a WPA project.

in corporate security issues; $218,704,000 in USHA loans for slum-clearance; $193,320,000 in RFC loans to private industry; $184,000,000 in federal-aid for highway construction; $40,000,000 in REA loans; and $4,628,000 in RFC loans for public improvements.

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Sales tax collection fails in Mississippi

The effort of Carl Craig, tax collector of Mississippi, to collect more than $1,000,000 in sales tax allegedly due on state highway construction ended unsuccessfully last month when Circuit Judge Julian Alexander of Jackson handed down an adverse ruling. The court held that Craig was without authority to bring the suit until an assessment of the tax sought had been made by Commissioner of Taxes Alf H. Stone.

Meanwhile the state auditor withheld $600,000 for work recently completed by highway contractors. Some of the contractors asserted that unless the funds are released they will be unable to continue construction now underway.

The sales taxes were sought on work being done as a part of the state's $80,000,000 highway construction program, which is financed jointly by the state and federal governments.

• • •

Long pipe line completed in the South

A 98-mi. pipe line extending from St. Joe, Fla., to Brainbridge, Ga., is now virtually complete. The line, which is being built by the Southeastern Pipe Line Co., is part of a pipe line extending from St. Joe to Chattanooga, Tenn.

There has been a court battle of several months in an effort to prevent the pipe line from crossing the state highways of Georgia (*ENR* Feb. 29, 1940, p. 297). Several months ago the attorney general of Georgia ruled that the Georgia State Highway Department had the power to allow or deny the Southeastern company the right to cross that state's roads with the line. The railroads were also fighting its construction.

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Maryland would end road sign nuisance

The Maryland Legislative Council has approved a bill for possible legislative action empowering the Maryland State Roads Commission to rid highways in that state of illuminated billboards when these are found to constitute a menace to safe driving. The measure, which will be placed before the state legislature, would also increase fees on permits for roadside signs and would authorize the commission to regulate their size and location. Under the terms of the proposed bill the commission could refuse to issue a permit for billboards not conforming with the safety requirement stipulated and, upon 15 days notice, could require the removal of existing billboards not meeting the standards.

Heads The Austin Company

George A. Bryant, executive vice president and general manager of The Austin Co., Cleveland, since 1930, has been made president and general manager of that organization. He succeeds the late W. J. Austin, who was killed in a plane crash at Chicago on Dec. 4 (ENR, Dec. 12, 1940, p. 788). Mr. Bryant received his engineering education at the University of Illinois and first became associated with the Austin firm as field engineer 27 years ago on a building job in Alberta, Canada. He was named district superintendent for all Austin operations in New England in 1916 and shortly thereafter became manager of the company's Philadelphia office.

On America's entry into the World War Bryant was placed in charge of the company's offices in New York, Philadelphia and Washington. Later, in 1918, he was made general sales manager for the entire company, a job he kept until early this year.

As general manager of the company for the past eleven years, Mr. Bryant has been in charge of the design of buildings, letting of contracts, securing materials, and field construction operations.

BRIEF NEWS

EACH MILE of the state highway system in Illinois is costing $1.68 a day for maintenance, according to chief highway engineer Ernst Lieberman. The total for the 13,610 miles in the state system was $4,556,000 during the first eight months of 1940.

THE OHIO Department of Highways has initiated a state-wide program to conserve trees along the 8,000 miles of the state road system. The work, under the direction of Dallas D. Dupre, Jr., includes removing trees of medium size where construction work would ordinarily call for their destruction.

THE MEXICAN SENATE has approved a bill calling for a $610,000 increase in federal highway bonds to finance the construction of a trunk highway that will connect Guanajuata City, an important central mining center, with the ports of Tampico on the Gulf of Mexico, and Zihuatanejo on the Pacific. The latter port is to be the southern terminal of the railroad the government is building from central Mexico.

THE PEOPLE'S Water Service of Baltimore, Md. has purchased the water properties of the Mississippi Power & Light Co. at Senatobia and Charleston, Miss.

C. W. PHILLIPS, highway commissioner of Tennessee, has announced that Tennessee's 1941 road construction program is estimated at $9,626,000. This includes only the expenditure of federal and state funds on strictly federal-aid projects. The work calls for 51.4 miles of grading and drainage estimated to cost more than a million dollars; 17.7 miles of paving estimated at $870,000; 10.6 miles of surfacing at $250,000; and four bridges estimated to cost $450,000.

LAST MONTH in the presence of 300 engineers from all parts of Canada a co-operative agreement was signed between the Association of Professional Engineers of Alberta and the Engineering Institute of Canada.

THE CITY COMMISSION of Jacksonville, Fla., has voted to purchase the Lake Shore water system at a cost of $17,500.

THE PUBLIC SAFETY COMMITTEE of the board of aldermen of the city of St. Louis has reported favorably on a bill to allow the minimum required thickness of building curtain walls to be 9 in. instead of 13 in. as previously required. The change is favored by the St. Louis Housing Authority, which claims that the change will save $180,000 on two USHA projects in that city. The proposed amendment is opposed by the Bricklayers Union, mason contractors and brick manufacturers as a menace in case of a tornado. The measure is to be acted upon by the board of aldermen Jan. 10.

A LAW giving the Florida State Road Department several thousand miles of Florida highway built on right-of-way which was never formally acquired by the state, has been upheld by the Florida supreme court. Constitutionality of a 1935 statute was at issue.

WASHINGTON HIGHLIGHTS

MORE UNIFORMITY in local plumbing codes will be encouraged, the Central Housing Committee hopes, as a result of publication of its new plumbing manual. The manual is intended primarily for the use of federal agencies which design, install, or use plumbing, but it covers substantially the same ground as most plumbing codes and is expected to have an influence on them. Although it has not proved possible to fix standards entirely in terms of performance as contrasted to specified dimensions, the manual goes farther in this direction than do most codes. This is particularly the case as to approved methods of venting and required sizes of soil and waste stacks and of building drains and sewers. Here more latitude than usual is allowed the designer with the hope that economy will result. The publication, which is largely based on Bureau of Standards research, is published as BMS66 in the Bureau's series on low cost housing materials. It can be obtained from the government printing office in Washington for 20 cents.

CONSIDERATION is being given to the possibility of awarding the construction contract for the garrison at the Newfoundland naval base to Canadian contractors. A final decision has not yet been reached and the matter is being thrashed out in the War Department and the Defense Commission. Although Canadian reports assert that bids had been invited from Canadian firms, it is stated in Washington that applications were unsolicited. If it is decided to use a Canadian firm, the motive will apparently be international amity rather than any lack of available firms in this country. As soon as it became known that the Corps of Engineers would have charge of the work, the Corps was flooded with applications from contractors. The Corps assembled data on the applicants, and within a few weeks it has built up a substantial file of contractors. Negotiated contracts will be awarded from this file rather than through the machinery established by the Quartermaster Corps' Construction Advisory Board. It is possible, however, that some of the contracts will be awarded on competitive bids.

• • •

Lavis to report on Latin American work

Fred Lavis, consulting engineer of New York, has been asked by Nelson Rockefeller, coordinator of commercial and cultural relations between the American republics of the Council of National Defense, to prepare a report on "Internal Transportation and Intercommunication in Latin America." Lavis is adviser on transportation to the minister of public works of Venezuela, and has been making investigations of various transportation projects in that country during the past two years. He recently celebrated the 50th anniversary of his first service in railway and highway construction in Latin America.

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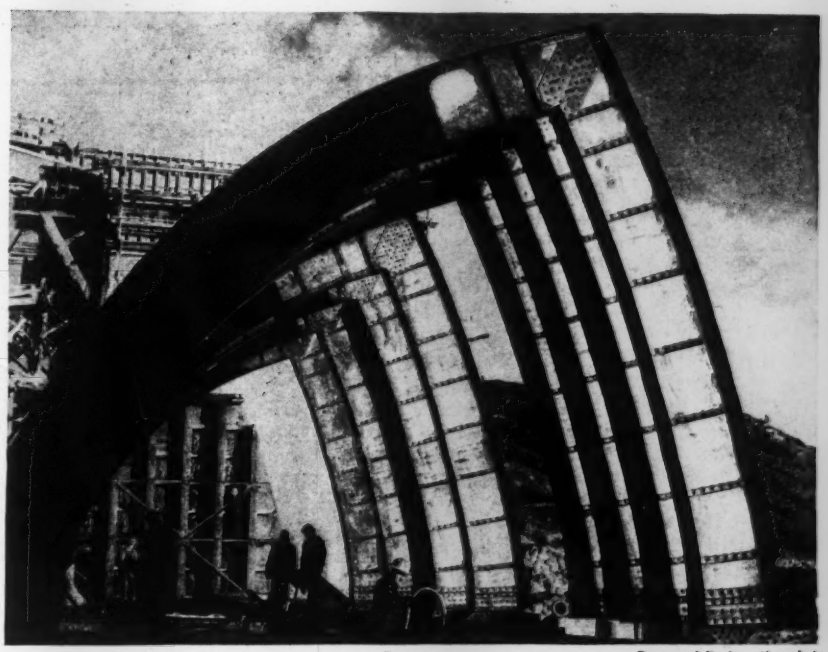
Bids asked for link of Trans-Canadian road

The Province of Ontario, in its first extensive departure from a no-capital expenditure policy during the present war, last month called for tenders on a 150-mile stretch of highway between Geraldton and Hearst, tenders to be submitted by Jan. 9. This is the uncompleted link in the Trans-Canadian highway. Cost is estimated at $6,000,000.

The bids were asked by R. M. Smith, deputy minister of highways, and are to be based on standard provincial highway gravel construction.

A 25-mile stretch of the route from Long Lac, near Geraldton, has been under construction since January of last year.



Bureau of Reclamation photo

Drum gates top Grand Coulee Dam

Work is advancing rapidly on erection of the eleven 135 ft. by 28 ft. drum gates to control flow over the spillway of Grand Coulee Dam on the Columbia River in Washington. The drum gates by adding 28 ft. of storage above the spillway will increase the reservoir capacity by 32 per cent. Control equipment will provide for automatic, manual, or push-button remote control of the gates, depending upon which is desired.

Detroit engineers lay new building cornerstone

Construction on the new headquarters for the Engineering Society of Detroit in the Horace H. Rackham Educational Memorial Building has reached the point of laying the cornerstone. The ceremony took place Dec. 20 with James W. Parker, the society's president, presiding. Distinguished guests were Alex Dow, president of The Rackham Engineering Foundation, Alexander G. Ruthven, president of the University of Michigan, and Bryson D. Horton, chairman of the trustees of the Horace H. Rackham and Mary A. Rackham fund.

• • •

MacDonald is Bay State public works head

Herman A. MacDonald has been appointed Massachusetts Commissioner of Public Works by Gov. Saltonstall to succeed John W. Beal, who has held this post for the past year and a half. Mr. MacDonald is a lawyer by training. From 1928 to 1932 he served as associate commissioner of public works, and was also chief secretary to Governors Cox and Fuller during their terms of office. Commissioner Beal had declined a reappointment.

Navy has record construction program

Public works contracts awarded by the Navy's Bureau of Yards and Docks during the year ending last July were more than twice as great as during the most active previous year—1918—and more than ten times as great as during the most active previous peacetime year, which was 1934. During fiscal 1940, 688 contracts were awarded totalling $183,762,000, as compared with $89,093,000 in 1918 and $16,695,000 in 1934. The work for fiscal 1940 includes none of the large appropriations of last summer—particularly the $111,804,000 for naval airbases.

Designs and specifications were prepared in fiscal 1940 for more than three times as much public works as in any previous year. Major design trends during the year were standardization of many plans and specifications and adoption wherever possible of regular commercial grades of materials. Rigid frame design was used more and the use of welding increased in drydocks, caissons, and buildings. A start was made on design of bombproof structures.

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U. S. Engineers abolish Gulf division

The Gulf division of the U. S. Engineers with headquarters for 25 years at New Orleans will be abolished Jan. 15 as a national defense consolidative measure, according to army officials. The personnel of the division office will be moved and the division, which extends from Mobile, Ala. on the east to Galveston, Tex. on the west will be divided among three existing districts. The New Orleans section will be under the control of the Lower Mississippi Valley Division, whose headquarters are at Vicksburg, Miss.; the Galveston area will be placed under the Southwestern division office at Little Rock, and the remainder turned over to the South Atlantic division office at Richmond, Va.

• • •

Missouri River span operates at $10,700 loss

During the first year of its operation, the new highway bridge over the Missouri River at Rulo earned but $15,306 or $10,700 less than the total annual expense of $26,000. Of the total expenses, interest charges approximate $19,500.

Officials of the structure point out, however, that roads leading to the bridge were blocked for weeks due to a severe winter and that the Falls City, Neb.-Rulo, Mo. highway had been closed for months due to a construction job.

JOBS OF THE WEEK

SHIPYARDS, Portland, Ore.

Bureau of Yards & Docks, Navy Department, Washington, D. C. awarded the contract for constructing the shipyard expansion to the Williamette Iron & Steel Corp., Portland, Ore. The work is estimated to cost $1,000,000.

SHIPYARD FACILITIES, Pascagoula, Miss.

Ingalls Shipbuilding Corp., Pascagoula, Miss. received a contract from the Navy Department for constructing a $2,000,000 shipyard expansion.

SHIPYARD, Chester, Pa.

Sun Shipbuilding Co., Chester, Pa., received a contract from the Navy Department, Washington, D. C., for expansion of the shipyard facilities, work which is expected to cost $2,500,000.

HOSPITAL, Fort Benjamin Harrison, Ind.

Leslie Colvin, Indianapolis, Ind., was awarded a $1,596,300 contract for constructing 1,000-bed hospital at Fort Harrison for Constructing Quartermaster, Fort Benjamin Harrison. McGuire & Shook, Indianapolis, are architects for the work.

HOUSING, Coco Solo and Balboa, Canal Zone

Leonard Constructing Co., Chicago, Ill. was awarded a $4,224,000 contract by Bureau of Yards & Docks, Navy Department, Washington, D. C., for constructing a 1,400-unit housing project for enlisted men and civilian personnel.

POWER PLANT, Washington, D. C.

Stone & Webster Engineering Corp., New York, N. Y., are installing an additional 50,000-kw. unit at the Buzzard Point Plant, for the Potomac Edison Co., Washington, D. C., under terms of a $3,000,000 contract.

HIGHWAY BRIDGE, Connecticut.

When the state of Connecticut received low bids Dec. 23, for constructing a 6,300-ft. reinforced concrete bridge over Thames River between New London and Groton. A. I. Savin Construction Co., East Hartford, Conn., was low bidder with a bid of $1,486,996 for alternate "A" for the substructure. The same firm with a bid of $1,320,798 bid low for alternate "B." On superstructure Harris Structural Steel Co., New York, was low with a bid of $2,254,925 for alternate "B" American Bridge Co., New York, in bidding $2,522,398 was low. C. J. Bennett, Hartford, Conn., is engineer for the project.

BAG LOADING PLANT, Pulaski, Va.

War Department, Washington, D. C. awarded a $6,756,399 contract for the architectural and engineering services, procurement and installation of equipment, and operation of a bag-loading plant to Hercules Powder Company, Wilmington, Del. It is to be operated in connection with powder plant at Radford, Va.

ARMY PROVING GROUND, Indiana

J. L. Simmons Co., Inc., Indianapolis, Ind., received an $8,000,000 contract for constructing a 60,000-acre ordnance-proving ground, including 120 buildings, for the War Department, Washington, D. C., Russ & Harrison, Indianapolis, are architects for the work.

TEMPORARY BUILDINGS and HOSPITAL, Battle Creek, Mich.

Owen-Ames-Kimball Co., Grand Rapids, Mich. will construct the temporary buildings and hospital at Fort Custer for the War Department, Washington, under terms of a $1,383,140 contract on cost-plus-fixed-fee basis.

INDUSTRIAL BUILDINGS, Keyport, Wash.

S. S. Mullen, Seattle, Wash. bid low with a bid of $587,331 for constructing four industrial buildings at the Naval Torpedo Station for the Public Works Officer, Puget Sound Navy Yard. The work includes a torpedo shop, a maintenance building, a garage addition, and a storehouse addition. Bids were opened Dec. 26.

SHELL PLANT, Ogden, Utah

Olson Construction Co. and Dobson & Robinson, Lincoln, Neb., were awarded a $708,500 contract by the Constructing Quartermaster, Hill Field, Ogden, for constructing a small caliber shell plant at Ogden Arsenal Depot. Total estimated cost of the work is $2,500,000.

DREDGING, Cooper River Tail Canal, S. C.

Atlantic Dredging & Construction Co., Washington, N. C., was awarded a $747,050 contract for the dredging in the Cooper River tail canal of the Santee-Cooper project of the South Carolina Public Service Authority, Charleston.

NOTE—Additional bidding and contract news on over 800 projects large and small appear in the Construction News Section beginning on page 87.

Waterworks men get sabotage warning at New York A.W.W.A. meeting

American engineers receive tribute from Manila official for and against waterborne diseases in Philippines

Waterworks men were cautioned to take immediate steps in providing sabotage safeguards by B. E. Sackett, special agent of the Federal Bureau of Investigation, who addressed a meeting of the New York section of the American Water Works Association on Dec. 21. Cautioning waterworks men not to underestimate the ability or knowledge of saboteurs, Mr. Sackett suggested that a survey of each system be made leading to the adoption of precautionary measures. Broad suggestions on what to do are outlined in a booklet available to plant officials on request to J. Edgar Hoover, director, Federal Bureau of Investigation, Washington, D. C., he said.

In a symposium on national defense which highlighted the meeting, J. L. Barron, director of the division of sanitation, Nassau County (N. Y.), department of health, said that his organization had compiled an elaborate record covering all elements of the thirty water supply systems in the county. Centralization of this information in the files of one agency would be very useful in the event of any emergency, he stated. Tobias Hochlerner, division engineer, Department of Water Supply, Gas and Electricity, New York City, reported that the department will install extra chlorinators at distribution reservoirs and is taking more frequent laboratory samples to insure the maintenance of high water quality in New York.

Sabotage of water utility service would most likely involve physical destruction of plant rather than attempts to poison or otherwise chemically impair water quality in the opinion of George Norcom, consulting sanitary engineer of New York. Mr. Norcom said that frequent laboratory analyses and the dilution ability of large volumes of water mitigated the use of poisons.

A visitor from the Philippine Islands, Juan Carlos, chief of the inspection section, Manila waterworks, paid high tribute to the American engineers whose efforts, he said, had wiped out waterborne diseases in the Philippines.

Canada convention assured

Norman J. Howard, president of the AWWA, and director of water purification at Toronto, Canada, gave assurance that the annual convention of the association would be held in Toronto next June. Already 400 hotel reservations have been made, he said.

Charles R. Cox, chief, bureau of water supply, state department of health, and chairman of the New York section, reported that membership totaled 443, second only to that of the California section which has 482 members.

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Seattle pontoon bridge withstands strong wind

The Lake Washington pontoon bridge at Seattle, Wash. withstood a 58-mph wind Dec. 21 without incident, according to Charles E. Andrew, consultant for the Washington Toll Bridge Authority. The draw span near the east shore quivered somewhat at the height of the gale which hit broadside, Andrew said, but at no time was the movement serious enough to halt traffic. End locks at the draw span were adjusted shortly after the quivering was noticed, and the motion all but ceased.

There may have been a side sway of several inches in the center of the bridge, Andrew pointed out, but explained that the structure was built to take a side sway of 2 ft. Motorists driving across the bridge at the height of the storm could feel no movement, although 4-ft. high waves were breaking across the bridge.

The movement noted was not that of individual pontoons but a mass shift of the entire floating portion.

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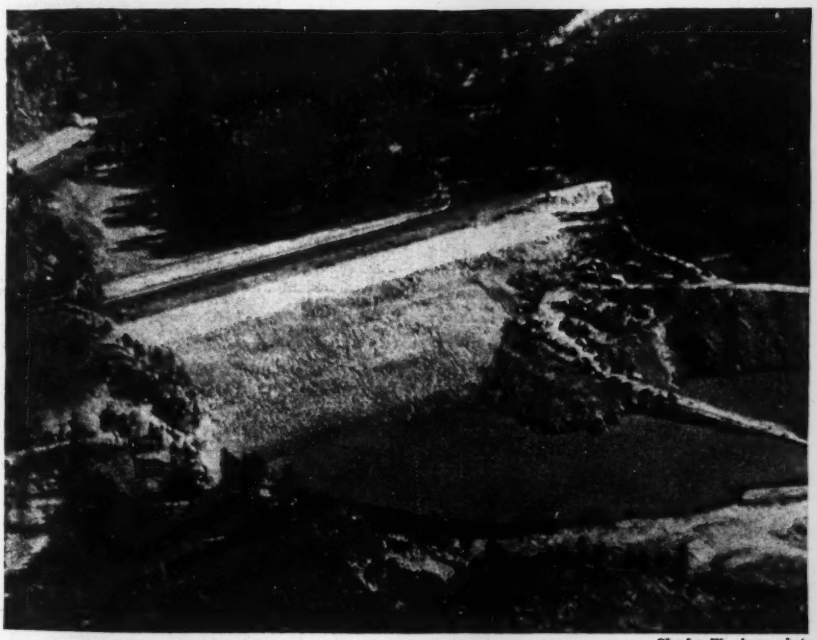
No record in steel orders during year

Orders booked by the fabricated structural steel industry during 1940 will probably not exceed a total of 1,700,000 tons, despite the recent increase in business resulting from the national defense program, according to the American Institute of Steel Construction. This compares with 1,305,049 tons booked in 1939 and 3,597,825 tons booked in 1929.

Looking ahead, it is believed the demands on the industry will not appreciably increase during 1941. Defense contracts, as pointed out by officials of the National Defense Commission, are now about 80 per cent let. A fair volume of this business is expected to continue for perhaps the next six months.



Charles Woodman photo

Lake of Pines Dam completed in South Dakota

Built at a cost of $400,000 with CCC labor, the Lake of the Pines Dam in the Black Hills of South Dakota has been completed. The earthfill structure, located about 20 miles southwest of Rapid City in the Harney National Forest is 126 ft. high from bedrock, and creates a 380-acre reservoir, which provides for 12,000 acre-feet of storage. The dam is 850 ft. long and has a maximum base width of 675 ft. During construction, flow was bypassed through a 600-ft. tunnel built by WPA workers, who also built the concrete spillway, fish ladder and settling basin.

Ben F. Powell, employed by the U. S. Forest Service, acted as general superintendent and engineer for the work. The dam was designed by James Brownlee, regional forester, U. S. Forest Service. The work was begun in August 1938, and 71,000 man-days of CCC labor were required.

OBITUARY

BEN M. SAWYER, chief commissioner for the South Carolina Highway Department, died on Dec. 22. He was a lieutenant colonel in the National Guard and has been stationed at Fort Jackson.

ANSEL L. PURPLE, of Columbia, Pa., died on Dec. 22. He was borough engineer and secretary of the Columbia Borough Council.

ALBERT H. UTTER, 71, civil engineer of Lincoln, Nebr., died Dec. 19.

WILLIAM H. CHAPMAN, 66, an inspector for the Milwaukee water department for 26 years, died Dec. 21.

CHARLES HENRY SMITH, sewer engineer for Portland, Ore., for nearly 20 years, died on Dec. 20. He began his engineering work with the Metropolitan Sewerage Commission of Boston, Mass., in 1890.

JAMES A. HANCOCK, superintendent of the Framingham, Mass., water department, died on Dec. 19. He was 59 years old.

WALTER G. WINDING, SR., aged 53 years, of Wauwatosa, Wis., died recently. He was president of the Winding and Slauson Construction Co.

DOMINIC A. CURIA, 34, Philadelphia, Pa., contractor, was killed in an automobile accident on Dec. 19.

CHARLES WILLIAM GALLOWAY, 72, vice president in charge of operations and maintenance for the Baltimore & Ohio R.R. for 20 years, died at his home in Baltimore, Dec. 15.

PATRICK W. FINN, 78, Pennsylvania contractor, died at his home in Huntington on Dec. 20.

ARTHUR V. SULLIVAN, assistant engineer in the bridge division, department of public works, Chicago, Ill., died suddenly at his home in that city Dec. 20.

FREDERICK WILLIAM MCENTIRE, district engineer for the Utah-Idaho Sugar Co., and founder and president of the Salt Lake Sodium Products Co., died at his home in Ogden, Utah, at the age of 56.

THOMAS H. MORGAN, Atlanta, Ga. architect, died on Dec. 22. He was a member of the firm of Morgan, Dillon & Lewis.

JOSEPH J. DICKMAN, 31, engineer of Kenmore, N. Y., employed by the New York state highway department, died Dec. 21.

CONTRACTS AND CAPITAL

ENGINEERING CONSTRUCTION awards for the short week due to the New Year's Day holiday, $82,544,000, are 54 per cent higher than in the corresponding 1940 week, and 10 per cent above last week. This is the eighteenth consecutive week in which current awards have topped their respective volumes of a year ago.

Private awards gain 45 per cent over the initial 1940 week and are 74 per cent higher than in the preceding week as a result of the increased volume of industrial building. Public construction tops a year ago by 61 per cent, but falls 11 per cent under last week. Federal awards are 523 per cent higher than last year, but 22½ per cent under last week.

In the classified construction groups, gains over the opening 1940 week are in waterworks, sewerage, bridges, industrial, commercial and public buildings, and unclassified construction. Increases over last week are in waterworks, sewerage, industrial and commercial buildings, and unclassified construction.

New capital for construction purposes for the first week of the new year totals $19,998,000. This compares with $50,281,000 reported for the corresponding 1940 week. The current week's volume is made up of $12,043,000 in USHA loans; $5,033,000 in state and municipal bonds; $1,620,000 in RFC loans for private industrial construction; and $1,302,000 in corporate security issues.

CONTRACTS

(Thousands of dollars)

	Week Ending Jan. 4 1940	Dec. 26 1940	Jan. 2 1941
Federal	$4,777	$38,307	$29,703
State & Municipal	26,986	18,985	21,446
Total public	$31,763	$57,292	$51,149
Total private	21,697	18,049	31,395
TOTALS	$53,460	$75,341	$82,544
Cumulative 1941	(1 week)		$82,544
1940	(1 week)		$53,460

Note: Minimum size projects included are: **Waterworks and waterways projects, $15,000; other public works, $25,000; industrial buildings, $40,000; other buildings, $150,000.**

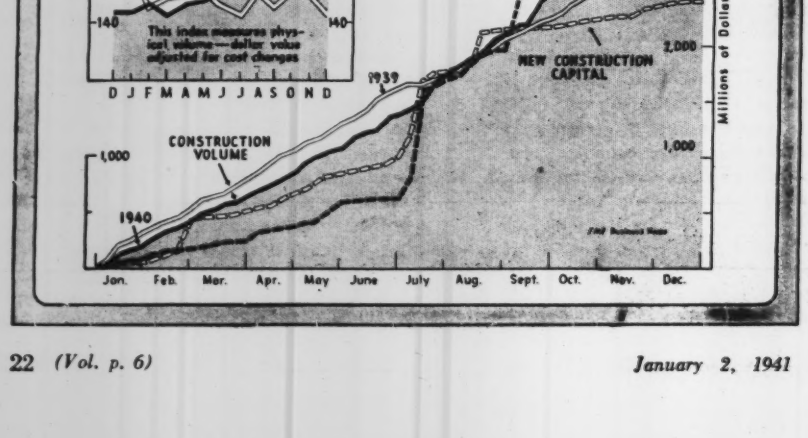
NEW PRODUCTIVE CAPITAL

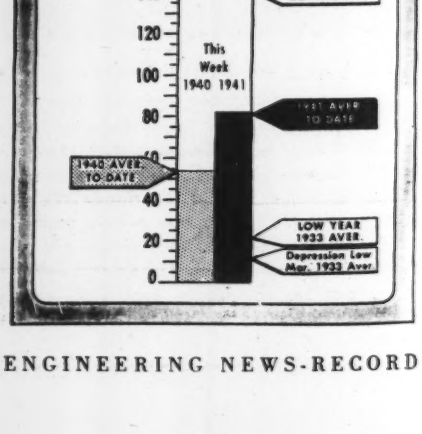
	Cumulative 1940 1 week	1941 1 week
NON-FEDERAL	$50,281	$19,998
Corp. Securities		1,302
State & Mun.	5,082	5,033
U.S.H.A. loans	45,199	12,043
R.F.C. loans		1,620
FEDERAL		
TOTAL CAPITAL	$50,281	$19,998

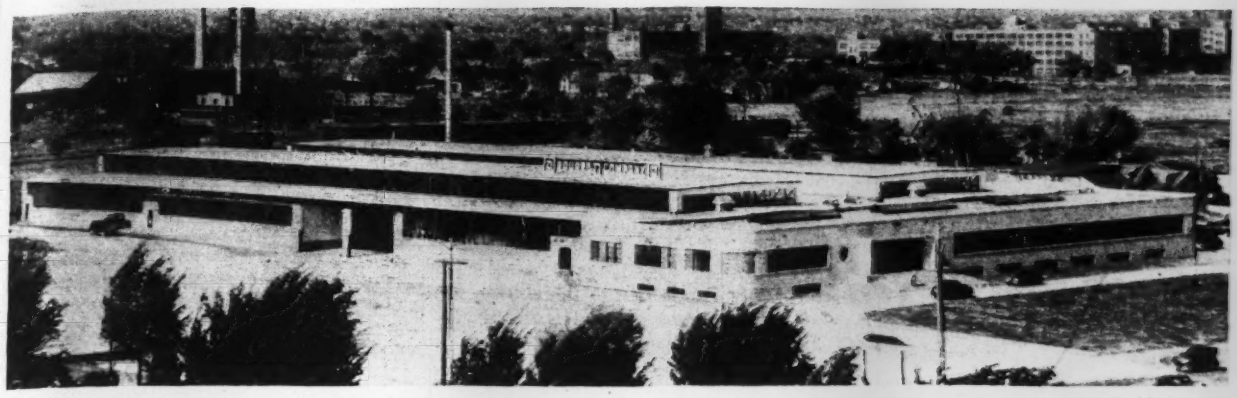
FHA MORTGAGES

	Week Ending Dec. 30 1939	Dec. 21 1940	Dec. 28 1940
Selected for appraisal	$9,697	$18,984	$12,182*
Cumulative 1940	(52 weeks)		$1,263,575*
1939	(52 weeks)		$1,123,791

* Subject to revision.







New plant is characterized by extensive power distribution facilities

For the new 125,000-sq. ft. Milwaukee plant for the Square D Co., the highest possible degree of flexibility and efficiency for the power distribution system was obtained through the use of 4,200 lineal feet of square-duct. This includes 500 ft. in the office portion where one installation serves the telephone system and another the lighting connections and office equipment. Feeder lines, which enter the plant through a dead front service distribution switchboard, are accommodated in concrete underfloor trenches designed with a slope to provide drainage for any condensation.

Another feature of the building, which houses the Milwaukee offices and all production facilities of the company's industrial controller division, is the modern architectural treatment. Buff face brick and limestone have been combined in curves and angles with continuous projected steel sash to provide an impressive modern facade across the streamlined office section shown at the right. The offices are air-conditioned and equipped for indirect lighting. Two air-conditioning units of 9,000 cfm capacity are required, the water being pumped from a deep well at 50 degrees for cooling. After passing through the sprays in the air-conditioning chambers, the water passes to a standing pond on the office roof, which will reduce the cooling load in summer. The water overflows from the roof for lawn sprinkling or to be wasted.

The manufacturing area, laid out for straight-line production in two 60-ft. monitor bays and three 40-ft. low bays with columns on 40-ft. centers lengthwise of the building, extends 380 ft. beyond the offices. Welded trusses are used.

The Austin Company, Cleveland, built and designed the new structure.

Philadelphia seeks $10,000,000 for airport

Officials of the city of Philadelphia are seeking $10,000,000 from the federal government for improvement of the Philadelphia municipal airport. The work would include $607,500 for filling and grading; $192,000 for drainage; $735,000 for four new runways; $102,000 for paving the taxi strips between the runways; and about seven million dollars for highway approaches. The Penrose Ferry road leading into Philadelphia would be a principal beneficiary.

Philadelphia once turned down a $3,500,000 WPA project to finish the airport.

• • •

New Mexico labor troubles ended

After a long period of fighting, the AFL and CIO forces are at peace in the state of New Mexico and, along with the Railroad Brotherhood, have agreed to work together for a five-point legislative program aiding labor. When the legislature meets Jan. 15, a united labor front will appeal for a little "Wagner Act" or an adjustment of the labor statutes to meet local conditions. A similar bill was defeated at the last legislative session when the three labor groups were backing separate programs.

The four other measures call for a bill establishing a "sound and workable" apprenticeship system; an amendment to the present wage collection law to allow the labor commissioner to go into justice of the peace courts to prosecute small wage claims of less than $200 (now these cases must be turned over to district attorneys for district court action); minor clarifications and changes in the workmen's compensation act; and a bill placing the office of the state mine inspector in the labor commissioner's office. The latter, it is believed will bring about closer coordination of effort, make for economy and better efficiency, and will avoid duplication of services.

• • •

Big street job approved at Columbus

A special committee of the council of the city of Columbus Ohio, has given approval to a street improvement program to be carried out jointly by the city of Columbus and Franklin County, with the state and federal government participating. The major work is construction of a new Sandusky Street bridge over the Scioto River, relocation of the New York Central R.R. tracks south of the span, and extending McKinley Ave. to Sandusky St.

The entire project, which is estimated to require two years to complete after construction is started, is estimated to cost $850,000 by City Engineer Paul W. Maetzel and County Engineer Allan C. Slade. Further details of the work are given in *ENR* Oct. 3, 1940, p. 435.

• • •

Connecticut road body has record year

The Connecticut State Highway Department closed 1940 with a total volume of work amounting to $16,000,000. During December, when bids were asked for a total of $6,000,000 of work, the department witnessed a record total of bids asked in one month. When contractors bid on a total of $4,500,000 worth of work December 23, bids were called for the largest estimate of contracts ever experienced by the department in a single day.

• • •

Beavers menace Montana town's water supply

By starting construction of a dam at the intake tunnel of the treatment plant, beavers recently menaced the water supply of the town of Great Falls, Mont. The animals had moved trees, about three or four in. in diameter, roughly 40 yd. upstream against the current to the intake. Five truck loads of trees, which formed the basework for the dam, had to be hauled away.

Comment and Discussion

Readers' opinions on matters that concern engineers and contractors

TACOMA NARROWS BRIDGE COLLAPSE

Sir: Your recent issues have carried many interesting communications relating to the Tacoma Narrows Bridge failure, but it appears to the writer that two fundamental features of the design have not been sufficiently emphasized. These are apparent upon examination of the details as contained in your issue of Nov. 21. First, the compressive flange of the plate girders was inadequately supported against transverse buckling. Second, there was inadequate resistance to torsional forces in the suspended structure.

1. Current practice requires that the top flange of a through plate-girder span be effectively supported against transverse buckling by efficient kneebraces at floorbeams or by other equivalent means. In a suspension bridge the compressive flange of the stiffening girder may have a length of from one-third to two-thirds of the span. The behavior of the girders in the Tacoma bridge showed distinctly a reverse vertical curve in each girder, with a node near the center of the span. This would make the flange a column possibly 1,000 ft. long with a slenderness ratio of about 3,000; such a column as a Euler column should buckle at about 30 lb. per sq. in. compression.

The girder had no kneebraces to the top flange, which was nearly 4 ft. above the floorbeam, and had no inner vertical stiffeners whatever between floorbeams, which were 25 ft. apart. The long wire rope suspenders could not enable the girder to receive appreciable transverse support from the cables.

2. A suspension bridge is always subject to the possibility of torsional stresses from wind or from unsymmetrical live load, and these are more likely to be severe if the girder is relatively shallow and therefore subject to considerable vertical deflection. The torsional resistance of the Tacoma bridge was almost negligible. The only sway frames were the floorbeams, and the plane of the single system of laterals was located near the neutral axis of the floorbeam, so that the laterals could not effectively develop transverse horizontal components at either top or bottom flange of the floorbeam.

FRANCIS P. WITMER
Director, Department of Civil Engineering
University of Pennsylvania, Philadelphia

Sir: While the recent failure of the Tacoma Narrows suspension bridge was a most regrettable and deplorable occurrence, much good will come from it in the advancement of engineering science if collective and constructive engineering thought is devoted to it. With this thought in mind we desire to inject into this problem a feature of the design of this bridge structure which, based on our own experience, we believe played an important part in this failure.

This feature, a recent new thought in suspension bridge design, is the use of shallow girders for stiffening rather than comparatively deep stiffening trusses. In our opinion it resulted in the difficulties experienced in recently constructed suspension bridges of long spans from undulations and also produced largely the out-of-phase movement of the two stiffening girders of the Tacoma Narrows Bridge.

The depth of the stiffening girders, 8 ft., provided a depth-to-length ratio of 1:350 in the vertical plane. With a 42-mph-wind there was an induced compressive stress in the windward girder of approximately 3,800,000 lb. These stiffening girders depend on the resistance of the main cables above to the tendency to buckle downward under compression and depend on the deck weight for resistance to upward buckling tendency under compression. Since the main cables are highly flexible and the weight of the structure was comparatively low it seems most probable that a tendency to buckle either upward or downward met with little resistance. When consideration is given to the fact that the undulations were present to accentuate and add to this natural buckling tendency or lightness, it seems inevitable that the two girders of the structure would get out of step resulting in the wreck. A difference between the two girders always existed when the wind blew, since one was functioning under tensile stress while the other functioned under compressive stress.

WILDER KENAN
Matthews & Kenan
Consulting Engineers, San Antonio, Tex.

Sir: There are a number of interesting matters in your Dec. 5 issue regarding the Tacoma Narrows Bridge failure.

C. A. P. Turner in his letter refers to the Smith Ave. bridge failure in St. Paul. I find a description of this in *Engineering News*, Sept. 1, 1904, p. 192, and some pertinent correspondence in the following issues of Oct. 27, p. 385, and Dec. 8, p. 526. Mr. Turner himself wrote the original article. It is not entirely clear from this account why he should now say that the cyclone lifted "a corner of a long heavy span". If uplift caused the failure it would appear that it worked equally on all four corners. Today the span would hardly be described as "heavy". In the Oct. 27 issue R. A. Tanner gave further details regarding this span, and called it "a comparatively light structure". He had evidence to support the view that the wrecked span adjoining the 170-ft span and their common supporting four-leg tower were simply blown over sideways. There seems to be nothing in this case comparable to the Tacoma Narrows disaster.

Both before and after the collapse there has been much comment on the narrow width of the Tacoma span, and since the disaster there have been several dire pronouncements regarding the width-span ratio of 72. With only an estimated 2 ft. of lateral displacement in the middle of the 2,800-ft. span, the writer is at a loss to see any indication of weakness consequent upon the breadth. True, in the final stage when twisting developed, a greater spacing of cables might have prolonged the agony, but with the same stiffness longitudinally the outcome would have been no different.

With the undulations all developing in a longitudinal direction it would seem logical to believe that the unusual feature was the longitudinal flexibility and that corrective measures should look to minimizing wind

pressures, as through the contemplated fairing, and toward increased longitudinal stiffness. Your editorial of Nov. 21 properly calls stiffness a "vital factor". Mr. Rathbone in his letter emphasizes that there are three main elements entering into oscillation—or lack of it—namely, towers, cables and girders, and that it is their inertia and elastic characteristics that effect the final result.

Directing attention then to Mr. Rathbone's statement, to the elevation, cross-section and other details of the Tacoma Narrows bridge in your Nov. 21 issue (p. 45), and to the corresponding data regarding the George Washington Bridge (Trans. A.S.C.E., Vol. 97, 1933, p. 144 and elsewhere), there seems little to question in Dr. Bowers' statement that the Narrows bridge was "the most slender suspension bridge ever built, both laterally and vertically". Perhaps in the extreme articulation of its deck—horizontal wind truss chords passing through holes in the floorbeams and expansion connections between stringers and floorbeams every 60 ft.—there is more of Professor Wessman's "honor" in the George Washington than in the Narrows bridge. But including four 36-in. cables vs. two 17-in. cables and the respective dead loads in the comparison, to say nothing of towers and sidespans, there can be no question that the Tacoma Narrows Bridge was the most flexible long-span suspension bridge ever built, both laterally and vertically, and that this flexibility results from a general, even if not specific, dimensional slenderness.

HOMER M. HADLEY
Regional Structural Engineer
Portland Cement Association
Seattle, Wash.

Navy Housing at Newport

Sir: In the article "Navy Goes into Action on Housing" (*ENR*, Oct. 24, 1940, p. 534), there are two additional points that I think should be mentioned.

First, the general contract was with the Bureau of Yards and Docks, Navy Department, of which Rear Admiral Ben Moreell, (CEC) USN, is the Chief, and who in this case was the contracting officer for the Navy Department.

The other point concerns Commander R. V. Miller, (CEC) USN, who organized the job, negotiated the contract with the contractor, and made the recommendation which led to the placement of the contract. Commander Miller at that time was Public Works Officer of the Naval Training Station at Newport as well as Officer-in-Charge of Construction of the new Naval Air Station at Quonset Point, R. I. The Quonset job, of immense magnitude, developed so rapidly that he was transferred in order to devote his exclusive time to that contract in August, 1940, so it may be readily ascertained that the undersigned had little to do but to carry on the organized job which Commander Miller left to me, his successor at the Naval Training Station.

R. E. BASSLER
Commander, (CEC) USN
Public Works Officer
U. S. Naval Training Station
Newport, R. I.

Vertical curves

Sir: The intervals in correspondence, when the writers are so far apart as Brisbane and New York, are almost astronomically spacious.

This condition should make for suavity and self control, even if the subject were more controversial than that of vertical curves (*ENR*, March 28, 1940, p. 430).

Professor Furr may go up top. His routine is precisely the same as I developed from the first invention of the method in Wellington.

All the same, I still feel justified in challenging your more youthful correspondents to develop the simpler technique, no matter how fierce the joys of tossing differentials and integrals about in the lamp-lit hours.

In relation to Queensland practice, development is in the direction of longer and longer peak V.C.'s, enabling ever greater visibility to be realized.

A feature of office practice which is, so far as I know, unique, is the classification of a V. C. by radius in feet, and not by change of grade per foot.

The transformation is simply:

$$R = \frac{\text{Length of V. C. (ft.)} \times 100}{\text{Change (per cent) of grade}}$$

H. ELLIOTT BROWN
Board of Engineers
Brisbane, Queensland, Australia

Inter-American Highway

Sir: Your article on the Inter-American Highway in the Oct. 3 issue was particularly interesting to the Canal Zone contingent of your subscribers. It furnishes interesting facts and figures to present to acquaintances back home who so frequently inquire about how long it takes to drive to the Canal Zone!

A statement in the closing paragraph to the effect that an excellent road exists from David (Panama) to the Canal Zone should be questioned, however, to avoid erroneous impressions. As indicated on the map accompanying the article, half of the distance is paved (mostly "blacktop"), but even along this stretch the road is so narrow for long distances that two cars cannot pass on the pavement. There are also many turns that would not be found on an excellent road, judged by American standards. The worst stretch of this section, however, is being rebuilt. The last half of the distance from the Canal Zone to David certainly is not an excellent road by any standards. It is little more than a dirt road, very narrow throughout about half its length and full of bad turns. While it is passable the year around, except for occasional difficulties, it is very little used for pleasure driving and the air route is preferred. Trucks and small buses negotiate it on a more or less regular schedule although during the current wet season a large crop of oranges near David was threatened because trucks could not get through.

It is not the intention to belittle the efforts of Panama in connection with this highway. Considering the small revenue derived from the road and the natural difficulties of terrain, the Panamanian Government is rather to be complimented that a road exists at all.

The point remains, however, that the article would lead the average motorist to believe that in a short length of time he will be able to average 400 to 500 miles a day down through Central America. It probably will be a number of years before this is possible, but in the meantime, the announcement that it is possible to get through will open up wonderful opportunities to the motorist who is primarily interested in the trip itself rather than in how fast he can make it. Such a sightseeing motorist will no doubt find the road "excellent" all the way.

E. B. STEVENS
Balboa Heights
Canal Zone

EDITORIALS

VOLUME 126 NUMBER 1

January 2, 1941

A Happy Solution

THERE SHOULD BE SATISFACTION all around in the new set-up worked out to handle army construction, for by it the special abilities of the Quartermaster Corps and the Engineer Corps are united for the first time in the interest of a common objective—efficient construction work. To civilians, the prohibition against using engineer officers on army construction has never seemed logical. By the same token the proposal to take such work entirely out of the hands of the Quartermaster and give it to the Engineer Corps seemed to involve an unnecessary demobilization of the talent in the Quartermaster's construction division. The new set-up, by which needed engineer officers are transferred to the Quartermaster Corps, offers a happy solution. There is a job to be done, and quickly. By enlisting the executive, technical and construction abilities of officers of the Corps of Engineers, who have had continuous experience on huge peacetime projects, the organization for defense construction is greatly strengthened. By keeping the Constructing Quartermaster personnel on the job, no talents are lost. Army construction is in good hands.

Bristol Wants the Best

WHEN BRISTOL, CONN., appoints a city engineer early this year it should have the satisfaction of knowing that it has the best available man for the post, and not just a "local boy" trying to make good. Maybe a "local boy" will get the job—but if he does it will be because he is the best-qualified man and not merely a resident of long standing (and a friend of a friend at City Hall). Bristol wants a job done, and it wants it done well. Therefore, the town fathers have advertised an open, competitive examination based on: (1) a written test; (2) an oral test; and (3) training and experience. In adopting this method of filling an important post Bristol gives recognition to city engineering as a professional and career service, the exercise of which has no relation to residential status or political affiliation. In a good many municipalities, however, the "local boy" complex is still revered, and a quaint delusion persists that there is a Republican as well as a Democratic way of paving streets.

Snow on Divided Roads

SNOW REMOVAL from our highways now receives a large portion of the maintenance money spent in many states. Windbreaks are erected to prevent drifting, but much snow falls on the highway surface where it becomes a serious hazard, as present-day drivers feel entitled to drive at the maximum speed limit regardless of the road condition. Plows push the snow off the traveled way, but in doing this compact and pile it in such places that the surface drainage system of the road often fails to function: subsequent melting and freezing produce an extremely hazardous ice film. These conditions frequently are aggravated on divided highways whose cross-sections are more diverse and drainage systems more complex than the single-lane road. Consequently, it is encouraging to note that surface drainage designs of some divided highways, as described in this issue, now are based on providing space for snow storage. Road surfaces are crowned and ditches are so designed as to dispose of snow water without its flowing on the highway surface. Experience with these designs should lead to improvements that can be incorporated in future divided roads.

Alternate Instead of Secondary

HOW ARE WE GOING TO HANDLE the constantly increasing traffic that jams our main highways, making them inadequate faster than additions can be financed and built? Since every highway department is wrestling with this fundamental question without too much success, an experiment that is being tried out in Massachusetts is worth recording. The plan consists simply in marking routes over backroads that will take the motorist to his destination without encountering the congestion of main highways. Although the idea in itself is not revolutionary, one of the potentialities it suggests may well be. Instead of thinking of our secondary road system as a feeder to the primary system, why not think of it and plan it as an alternate system? Instead of worrying over the impossibility of building high-speed parkways fast enough, why not take the worst danger spots out of good secondary roads and make them safe for reasonable speeds? Instead of ignoring secondary roads as real traffic arteries, put good markers on them and promote their use. If some traffic can be

diverted from badly congested main roads, both primary and secondary systems will benefit. Another fact not to be overlooked is that duplicate or triplicate routes between given points are ideal for moving a mechanized army. The Massachusetts experiment and the fundamental change in road system planning that it suggests may be worth careful consideration.

Defense Construction and Then What?

FEW NEW YEARS IN MEMORY have meant as much as this one. Under the threat of a "terrible urgency", the nation, its industries and its people try harder than ever to pierce the veil of the future. What lies ahead? There is no satisfactory answer. What can be planned for? Principally work, and probably trouble.

To the construction industry on this New Year of 1941 work is no new thing. As the spearhead of defense it has been working at top speed for six months. In the year just past, contracts for heavy construction exceeded the 1929 totals. New munitions factories caused both public buildings and industrial buildings to jump 100 per cent above 1939; miscellaneous public works, partly as a result of a great airbase program, are up over 150 per cent. Bridges, highways and earthwork came close to the previous year's total, and only municipal waterworks and sewerage registered a loss. Even commercial buildings showed a substantial gain, and when residential work, which had its best year since 1929, is added, a grand total in the neighborhood of 8.5 billion dollars measures the construction year of 1940.

AND THIS IS JUST THE BEGINNING. Not for a decade have construction prospects been so promising as they are for 1941; only such an unexpected event as Germany's sudden and complete collapse could slow down our defense preparations and the construction activity that now dominates them. Work is what the construction industry has been waiting for. There will now be work, but there will also be problems. They concern the defense work to be done, and they concern the future of construction after that defense work has been completed.

Important as they are it is not the problems of the present, of the "building for defense" period, that loom large as one considers construction's future, for these defense construction problems are real. Because they are real and recognized, they can be grappled with and solved. But after defense construction, then what?

THERE IS A CLUE in the voices that are being raised here and there in behalf of post-war planning. But more of these voices should come from the construction industry, for its necessary planning involves a period that will antedate post-war. As soon as the factories, airbases, cantonments and shipyards are built, construction will cease to be the spearhead of the defense effort. Great sums of federal money will continue to be spent but they will go for products instead of plant. National income will remain high and, under a conventional business-cycle pattern, investment in private construction would replace public works. But high taxes, inflated prices and a scarcity of construction labor could alter this pattern and place a damper on private building. Then could result the paradox of general prosperity with a throttled construction industry.

THE IMPORTANT THING is to recognize that there is a period in the future, midway between the present tooling-up period for defense and the far-away period of rebuilding for peace, that may be critical for construction. Recognizing it, the problems that it may present can be outlined and measures taken in advance to meet them. Keeping costs down would seem to be one of these measures. Another would be to create a reservoir of trained construction workers. A third might be to get the post-war economic planners to include this intermediate period in their calculations so that they will not have a depressed construction industry to cope with when the war emergency is over.

New Year 1941 finds the construction industry doing a magnificent job of tooling the nation for national defense. The job in hand and in prospect, and the work and trouble that it entails, will take all the energy and enterprise that can be mustered. It will not preclude, however, some time for thinking about the future and planning to meet its problems. It must not, else the answer to the question of construction's future may be no work and all trouble.

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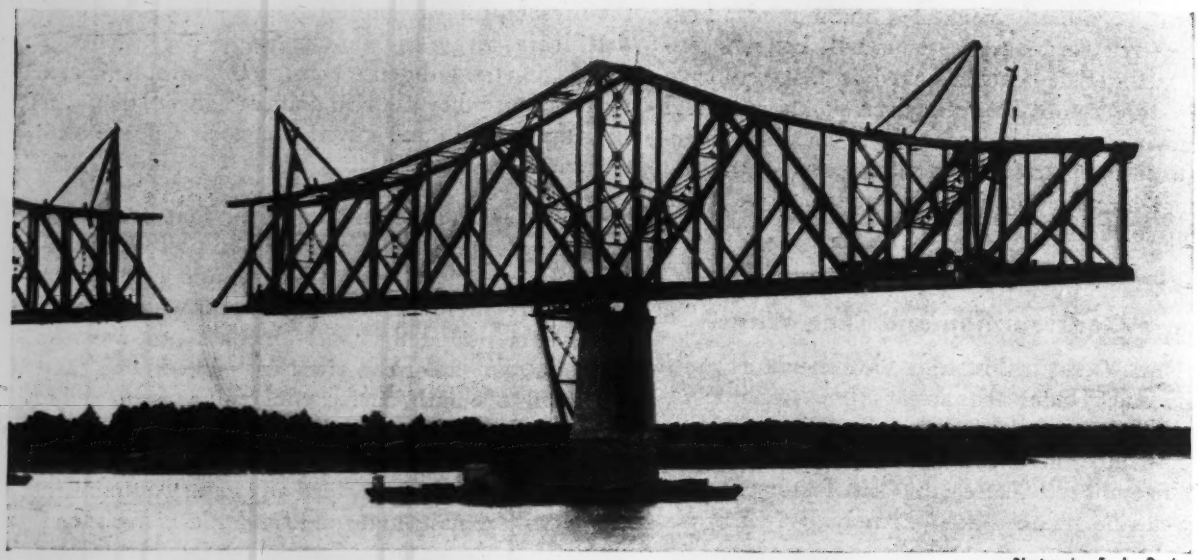


Photos by E. L. Durkee

Fig. 1. First stage of Baton Rouge Bridge erection nearing completion. Pier shown is No. 3.

Twin Cantilevers Erected by Balancing

E. L. Durkee
Resident Engineer

Lyndon F. Kirkley
Junior Erection Engineer

Bethlehem Steel Co., Bethlehem, Pa.

***Contents in Brief**—Deep water and deeper mud at site of new Baton Rouge Bridge over Mississippi River made falsework in stream out of question. Steel erected each way from piers, guy derricks starting work and assembling travelers which then carried on. Bridge is for both railway and highway use. Five spans of main river crossing vary from 490 to 848 ft. Only bridge crossing in the 180 miles between New Orleans and Natchez.*

ERECTION of the new railway and highway bridge over the Mississippi River 5 miles above Baton Rouge, La., was accomplished without the use of falsework bents in the river despite maximum span lengths of 848 ft. A single inclined bent at each pier supported the first panel of steel and thus provided a platform from which the derricks could start, but beyond this no falsework was used and erection proceeded by balancing steel each side of the piers. The method proved fast, economical and safe.

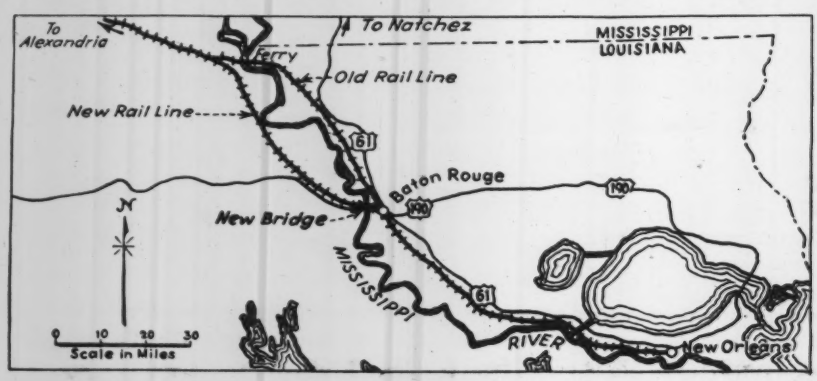


Fig. 2. Baton Rouge Bridge improves both highway and railway crossings of Mississippi, both previously effected by ferries.

The Baton Rouge Bridge is an important traffic link, replacing a highway ferry on U.S. 190 at Baton Rouge and permitting the Louisiana & Arkansas Railroad to abandon its old line on the east side of the river, which included a ferry crossing 40 miles upstream, and to use Missouri Pacific R.R. tracks on the west side of the river into Baton Rouge. Nearest adjacent crossings are the Huey Long Bridge 90 miles downstream at New Orleans and the new bridge at Natchez about an equal distance upstream. By its new routing the L&A saves an hour in time and eliminates long delays caused periodically by river conditions and fog on the ferry line. By locating the bridge 5 miles north of Baton Rouge, advantage was taken of a narrow width of the river, and in addition the site is beyond the limits of deep draft navigation which

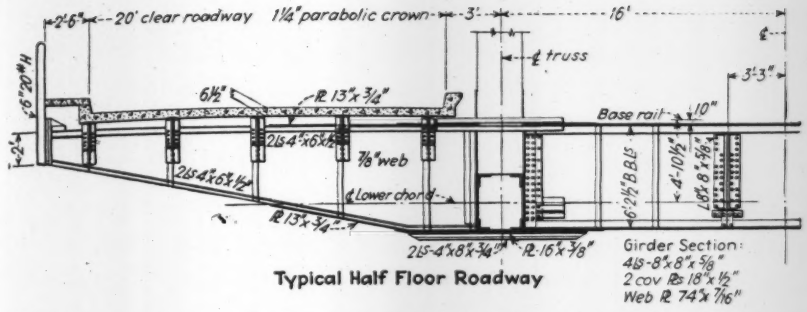


Fig. 3. Deck section of Baton Rouge Bridge, showing accommodations for both highway and railway.

permitted a 65-ft. instead of a 135-ft. underclearance for shipping.

Type and dimensions of structure

The main river bridge is a twin cantilever structure of 5 spans—490-ft. end anchor spans, a central anchor span of 650 ft. and two cantilever spans of 848 ft. which contain suspended sections of 396 ft. The trusses are 124 ft. deep at the piers and 62 ft. deep at the center. Approaches are a series of 83-ft.-span deck plate girders alternated with 43-ft.-spans on steel towers. The east railroad approach is 3,586 ft. long on a 1.13 per cent grade, the east highway approach 835 ft. long on a 5 per cent grade. The west railroad approach is 5,298 ft. on a 1.25 per cent grade and the west highway approach 1,719 ft. on a 5 per cent grade. On the main river bridge the railroad is carried between the trusses while the highways, designed for two lanes of H-20 loading, are outside on plate girder brackets. Dimensions are given in Fig. 3.

Of particular interest is the fact that all truss members are of built-up design; no eyebar tension members are used. Because of the heavy design loads and long spans some of the chord members weigh as much as 2,000 lb. per ft. Due to the heavy sections and joint details, a number of the top and bottom chord members were limited to one panel length and, including gusset plate connections at one end, weighed up to 42 tons each. Field rivets of 1-in. diameter with 8-in. grip were required for some of the joint connections. In general carbon steel rivets of 1-in. size were used for all principal truss, floorbeam, roadway bracket and bottom lateral connections; ⅞-in.-diameter rivets were used for portals, sway frames and top laterals. Main material in the primary truss members, floorbeams, roadway brackets and railway and highway stringers is silicon steel.

Construction of the piers and erection of the steelwork for the main river crossing was the most difficult and unusual part of the project, as is to be expected in any encounter with Old Man River in this locality. The two center river piers, Nos. 3 and 4, were built by the sand island method. Caissons for piers 1, 2 and 5 were sunk by open dredging. Construction of these piers was described in *ENR*, Jan. 20, 1938, p. 106. Caissons for piers Nos. 2 and 4 were sunk to the unusual depth of 180 ft. below low water.

Plan of erection

Erection was carried out in two distinct operations, Fig. 4. The first operation involved simultaneous balanced cantilevering over piers 3 and 4, then joining the center anchor span between these piers and leaving a cantilever arm and one half a suspended span cantilevered in the opposite direction from the piers. The second operation involved similar erection over piers 2 and 5, landing the shore anchor spans on piers 1 and 6, respectively, and then joining the suspended span halves to complete the structure.

No river falsework

The only falsework used was an inclined steel bent supported on the side of piers 2, 3, 4 and 5. Independent falsework was not considered because of river depths up to 80 ft. at low river stage between piers 2 and 4, unstable and unsatisfactory river bottoms for any temporary falsework supports, the excessive cost if it were possible to locate falsework, the hazards to navigation of placing any falsework bents in the river proper, and the dangers from flood and high water.

The inclined steel falsework was connected to the first bottom chord panel point, 40 ft. away from the main pier shoes, and to a temporary link and anchorages embedded in the pier caissons and shafts (Fig. 6). After closure of the center anchor span between piers 3 and 4 was made, the bents were removed from these piers, temporary connections burned off at El. +30 and under water, and the bents moved to piers 2 and 5 for similar use there.

Special precautions taken

This scheme of erection required special and accurate balance calculations. The falsework bents and bracing were designed to resist an unbalanced moment due to a load of 100 tons at the end of either erected arm at any stage of the work. This permitted some unequal progress in the balanced erection of steelwork and avoided delaying either of the two erection crews for minor out-of-balance conditions.

Provision was made in the design of the structure, in the falsework bents and in the piers themselves for wind loads in any direction, vertical as well as horizontal, and also for an unbalanced wind load on one arm of the structure. The resulting torsional stress was designed to be resisted en-

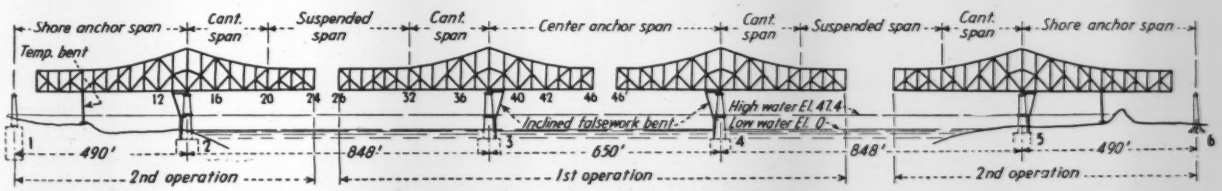


Fig. 4. Elevation of main river crossing of Baton Rouge Bridge, showing stages in the balanced-cantilever erection scheme, which required no falsework in the river.

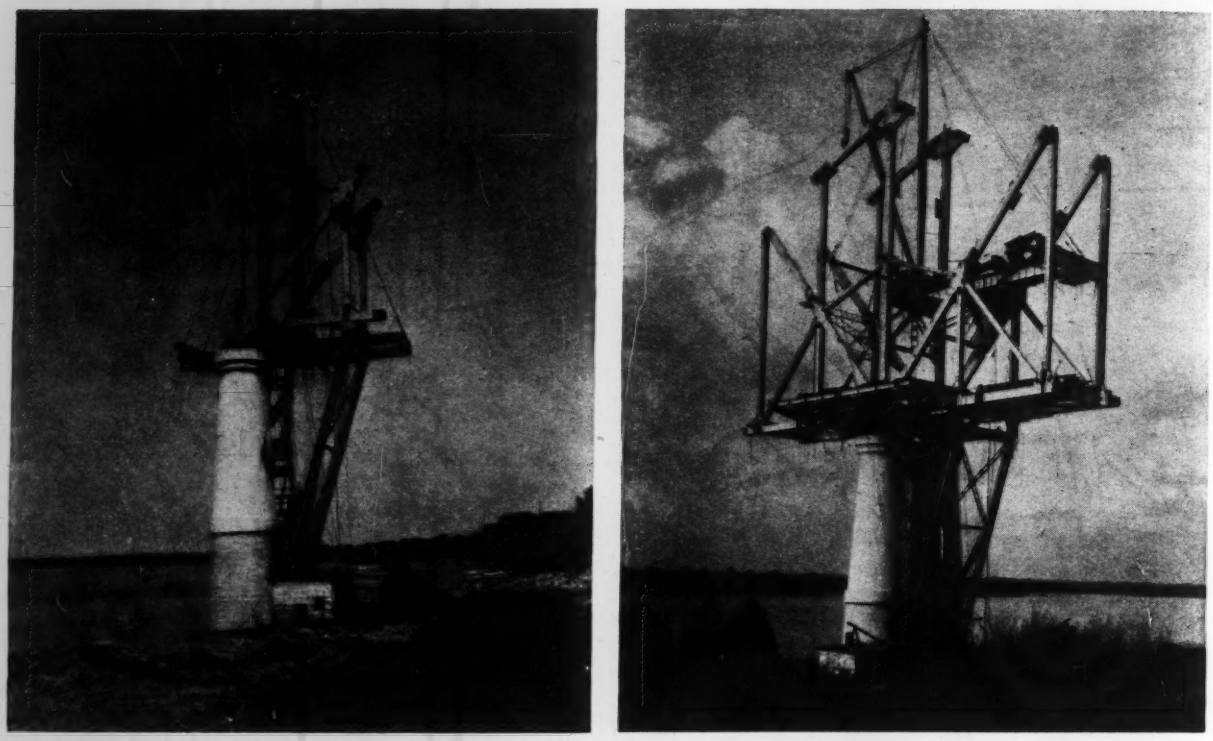


Fig. 5. Two stages in the start of balanced cantilever erection at Pier 2. Guy derrick in view at right subsequently assembled travelers which carried on the work as shown in Fig. 1.

tirely by the pier. No severe storms were encountered during the construction period.

A 95-ft. Chicago boom seated on the pier at about mid-height was first used to correct the inclined falsework bent and a temporary steel derrick platform at the top of a pier. The Chicago boom was then jumped to near the pier top where it was used to erect a 105-ft. guy derrick mast on the platform; finally it was stepped into the mast to make a 40-ton-capacity guy derrick.

With the guy derrick in this position (Fig. 5, left), the main pier shoes and a portion of the truss members in the two panels each side of the pier were erected. To reach the apex and top chords of the bridge truss over the piers, the guy derrick was jumped to a temporary platform of floorbeams and stringers 50 ft. above. From this point (Fig. 5, right), it completed the two panels of trusses each side of the pier and erected a second derrick ready to start the simultaneous balanced cantilevering. At this time the guy derrick was converted into a special type stiffleg traveler designed especially for this job. The base of the traveler rested on a platform which moved along on the railroad rails while the stifflegs followed the inclinations of the top chords as shown in Fig. 1. Hoisting power for the two erecting derricks was supplied from engines on barges anchored at the base of the piers. By careful control during the progressive cantilevering, the unbalanced load was kept within allowable limits, and for the first operation steel was erected 325 ft. each way from piers 3 and 4 with no other falsework. After the center anchor span had been connected, cantilever erection proceeded to 425 ft. (taking in half of the suspended spans) before removal of travelers.

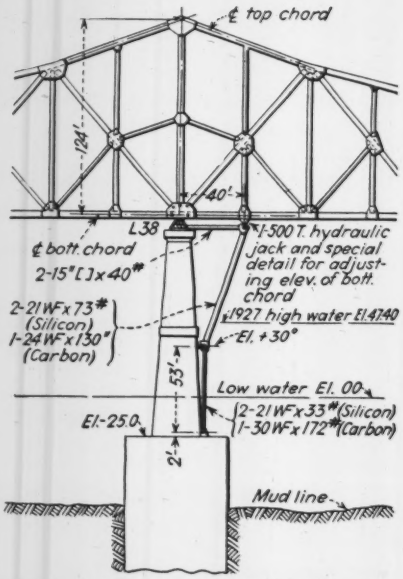


Fig. 6. Details of the inclined falsework bent which supported steelwork for entire balanced cantilever erection over main piers.

During the first operation (Fig. 4), expansion shoes and rollers over pier 4 were locked in a retracted position in order to increase the final opening at the center of the span between piers 3 and 4 by 5 in. The half span arms of this center anchor span were also kept in a slightly raised position from a true horizontal by adjustment of jacks on the inclined falsework bents one panel out from each pier. This permitted easy entering of the closing bottom and top chords. Closure was made by unlocking the expansion shoes on pier 4, lowering the four 500-ton hydraulic jacks at the inclined falsework bents (one jack under each truss) and by pulling the steel over pier 4 toward pier 3 by hydraulic jacking devices on the bottom chords at L46.

On the second operation, covering piers 2 and 5, balanced cantilevering

was carried out to the shore piers 1 and 6 (490 ft.) before joining the two halves of the suspended spans between piers 2–3 and 4–5. A single steel falsework column, founded on timber grillages on shore and carried on two 200-ton wedge jacks and one 350-ton hydraulic jack for adjustment, was used under each truss to assist in landing on piers 1 and 6, respectively, and to relieve some of the temporary erection stresses that would have occurred had only the inclined falsework bents at piers 2 and 5 been used. Landing of the shore anchor arm spans was made by lowering the falsework bents on shore. The columns of these bents had been kept adjusted slightly above normal elevation for this purpose.

Closure of the suspended spans between piers 2 and 3 and piers 4 and 5 was effected by single 500-ton hydraulic jacks and special details temporarily built into the top and bottom chords at U20, U32 and L32, where permanent provision has been made for truss expansion and contraction. After closure, temporary details and jacking equipment were removed.

The entire superstructure of the bridge, including approaches, required about 35,000 tons of fabricated steel, of which 20,000 tons was used in the main spans between piers 1 and 6.

Engineers and contractors

Construction of the six main span piers was performed by the Kansas City Bridge Co., Kansas City, Mo., on a contract of $2,421,980. Fabrication and erection of the main span superstructure including railway track, roadway paving and painting, was completed by the fabricated steel construction division, Bethlehem Steel Co., at a contract price of $3,705,855. Approach foundation work was handled by the Uvalde Construction Co., Dallas, Tex., and approach superstructures by the Steel Construction Co., Birmingham, Ala.

The entire bridge project was designed and contracted for by the Louisiana Highway Commission, for which H. B. Henderlite is state highway engineer, N. E. Lant, bridge engineer, and E. L. Erickson, assistant bridge engineer in charge on the site. The total cost of the bridge including highway and railway approaches approximates $9,500,000. Harrington & Cortelyou, Kansas City, acted as consultants.

Wood Augers for Subsurface Test Borings

Henry D. Hammond
Assistant Engineer, Department of Public Works, New York City

LARGE WOOD AUGERS were used to supplement usual test boring equipment in exploring the site for a building at the foot of Grand St. on the East River in New York City. The contemplated building, to accommodate the crew of a fireboat, is only medium size, loads are light and previous work at the site indicated good bearing was available on original ground at moderate depth partly through fill material.

It was expected that two or three borings would be sufficient to give the necessary subsurface data. Soundings over most of the area of the site, however, were abruptly stopped at depths ranging from 12 to 21 ft. by wood too heavy to be pierced with the usual chopping bits and methods employed with a small casing.

Despite lack of precedent, it was decided to try wood augers. A 4-in. casing driven to the obstructing timber was planned to start the borings. A 3½-in. double-bit auger was welded to a standard rod coupling, it being planned to bore through the highest wood encountered, introduce 2½-in. casing, and then, if further wood were found, employ a 2-in. ship auger, which was also welded to a rod coupling. If this second hole did not weaken the timber so that the 2½-in. casing could be driven on down, further penetration could at least be secured by driving rods and a sample spoon.

The auger was assembled to turn clockwise, corresponding with the threading of the standard drill rods. The speed of the slowest rock drills is much too high for such augers, and sunken timber is apt to be full of nails and bolts, so pipe wrenches were used to turn the auger, grasping the drill rods just above the casing. It required less time to bore 8 or 10 in. of wood in this way than is necessary to chop through with the standard 2½-in. chopping bit operated in a 4-in. casing. As the auger could not be backed out without uncoupling the rods, and as it was desired to recover all of the chips possible to determine the condition of the wood, the bit was driven up and out by reversing the action of the drive hammer weight.

The wood encountered in at least three of the borings was evidently part of old ship's hulls. It was not necessary to use the smaller auger at all, as practically clear water was found between the deck and bottom of the hulls in all three borings. The large auger was worked down to the second layer of wood, unprotected by casing, and used to bore through it. Enough chips were recovered to show that the wood was pine, and in the same condition as that of the deck. The auger suffered remarkably little damage in the process, and it was not necessary to sharpen it during the entire job. The 2½-in. casing was inserted through the holes in the deck and bottom of the hulls and carried on down to good bearing on original material.

The New York City Department of Public Works, under Commissioner Irving V. A. Huie, carried on the boring work described with its own forces, organized under direction of J. Frank Johnson, chief engineer. Girard E. Wheeler, assistant geologist, is chief of the boring section, with the writer in charge of the field work.

Ship augers of 3½ and 2-in. size welded to drill rods are used to cut through subsurface timber. Note recovered samples of the wood encountered.

Fig. 1. Fills are compacted largely by hauling and spreading equipment on Wheeling, W. Va., airport.

Class 3 Airport Built on Hilltop

***Contents in Brief**—Three million yards of material are being moved to build a Class 3 airport at Wheeling, W. Va. WPA labor is used under a unit price contract agreement unique in pattern but moving earth, shale, and limestone for less than 28c. per yd. of which 12c. goes to the contractor for supervision, shovel operators, and equipment.*

LOCATED on a generally fog-free hilltop about 11 miles north of Wheeling, W. Va., and on the main TWA airline course, a new airport is scheduled for completion in March, 1941. Despite a terrain requiring cuts of 100 ft. and fills up to 140 ft. it has been possible to design a 5200-ft. runway, almost exactly in line with the prevailing wind and two others 3,200 ft. long, both of which may be extended to 5,000 ft., following natural ridges.

An unusual contract arrangement permits the contractor to use WPA-paid relief labor and sponsor-paid non-relief labor. Under this arrangement more than 2,500,000 yards of material have been moved, well ahead of contract schedule and substantially below the estimated cost.

Class 3 airport

Design of the port conforms closely to the CAA requirements for Class 3 airports (*ENR*, July 4, 1940, vol. p. 13). As shown in Fig. 4 the landing strip in the prevailing wind is 3,700 ft. with an extension to 5,200 ft. now recommended from money available due to construction economies. The port is situated above most of the surrounding territory and is comparatively free from fogs, seldom having one when the Pittsburgh port, 60 miles distant, is in difficulty.

Fig. 2. A 1½-cu.yd. shovel loads blasted excavation on 6-cu.yd. hauling unit.

The port has graded runways 500 ft. wide with ground above the runway level sloped at 1 to 10 outside this width. Landing strips are 100 ft. wide with 2-course asphaltic concrete surfacing on a crushed stone base. Runways slope 1 percent in each direction from the paved strip to shallow gutters outside the 500-ft. width, providing rapid surface drainage. Drainage under the paving is provided by herringbone pattern crushed stone French drains about 1 ft. square as shown in Fig. 4. This water is collected in cross-drains at low points and discharges through gutters over the slope. Drainage is provided under all of the fills by French drains leading into 10 and 12-in. tile. Only one point in the field carries drainage from an area above the port; here a 48-in. extra heavy concrete pipe is used under a 90-ft. fill.

Special management contract

The work agreement has the following provisions: (1) The contractor shall provide all equipment, material, supplies, and repairs required except explosives, exploders, fuel oil, gasoline, lubricants, and anti-freeze compounds (to a stipulated amount, about $0.0445 per cu.yd.). (2) The contractor shall sup-

ply and pay the shovel operators. (3) The contractor may select 30 skilled non-relief men to operate major construction equipment and to be paid by WPA. (4) WPA will supply 31 skilled relief workers, truck drivers, mechanics, powder men, etc.; 42 intermediate workers, oilers, drillers, etc.; and 83 unskilled workers. (5) The contractor shall be paid $0.1205 per cu. yd. on monthly estimates as compensation for supervision, equipment, public liability insurance, workmen's compensation (on his own payroll only) and miscellaneous supplies.

Further provisions require that the contractor shall avoid peaks and valleys in employment, but arrange the schedule so that all men furnished by WPA work not more than 8 hr. per day 40 hr. per week, and neither more nor less than 130 hr. per calendar month. He shall pay not less than WPA rates to his own employees and follow the same working schedule. The contractor shall segregate the stone suitable for base material, but crushing and placing is done by WPA under its own direction. Rolling of fill is at the option and expense of the sponsor. The contractor may select skilled or semi-skilled employees from those in the lower classifications furnished by the WPA and may use WPA men as labor foremen or for other minor supervisory positions.

Equipment is contractor's

The contract specifies certain minimum equipment, which is generally exceeded by that in use. Best quantities for any month, although nearly equalled during each summer month, were recorded in July, when two 12-yd. and one 8-yd. carrying scrapers moved 85,873 yd. of earth; a 2½-yd. shovel loaded 83,726 yd. and a 1½-yd. shovel handled 66,583 yd., largely shale and limestone; a total of 236,182 yd. in two 7-hr. shifts daily. Available for hauling from the shovels were five 12-yd. trucks, two 14 and one 10-yd. track wagons and two each 5 and 6-yd. end-dump, wheel-tractor-mounted hauling units.

Bulldozers, a motor patrol grader, drill sharpener, 6 portable compressors, and a water truck hauling from Wheeling, complete the contractor's major equipment. The project sponsor provides trucks for stone hauling and two 60-passenger buses for transporting employees (relief and non-relief) from Wheeling and nearby points.

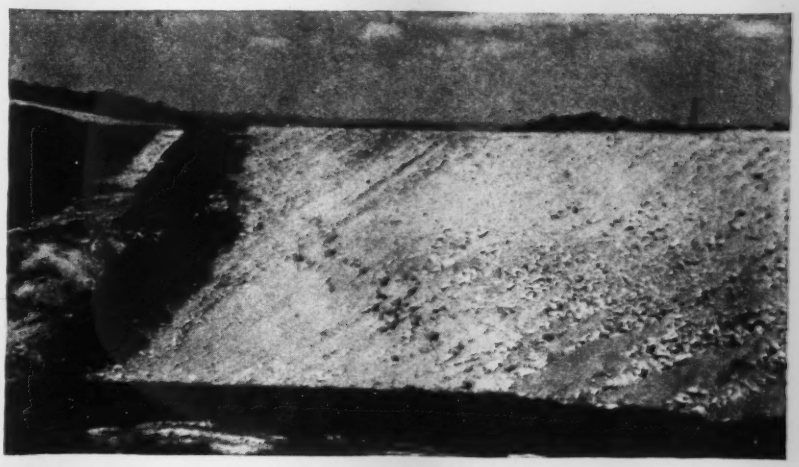


Fig. 3. Fill 140 ft. high levels out rugged hilltop for Wheeling airport.

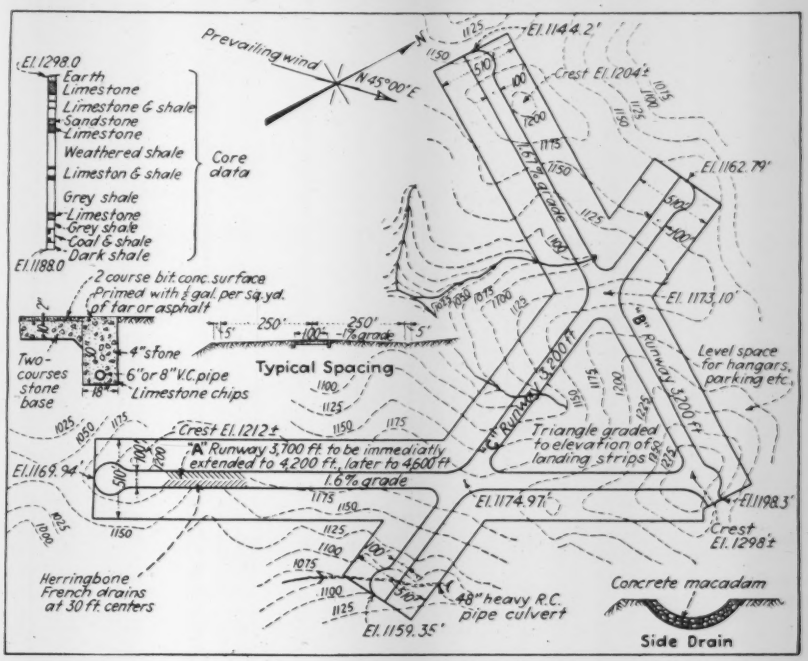


Fig. 4. Three million yards of material are being moved to provide about 2 miles of 500-ft.-wide runways.

The personnel on the project agree that unusually good cooperation must exist between the agencies involved to make the management contract operate satisfactorily. WPA routine has been speeded up and some enthusiasm instilled in the workers but it is admitted that there is room for improvement. Semi-skilled and skilled WPA labor do not keep the pace set by those who are hired, and can be fired, by the contractor. Relief employees can be discharged, subject to review, but transfers are a simpler expedient for disposing of laggards on the work.

All surfacing is done by WPA forces, who also supply the equipment for stone handling and crushing. A patrol grader cuts the 100-ft. runway width to accurate crown, while hand trenching provides the herringbone pattern side drains. Crushed stone is placed to form the French drains and tile used for major drainage in the sides as shown in Fig. 4. The subgrade is rolled with a 10-ton 3-wheel roller, following which the base is laid in two courses rolled to 5-in. thickness each. Material used is crusher-run from a job plant, 4-in. max. size.

Stone is secured from storage piles left by the excavation contractor. It is hand-loaded and hauled up an overhead ramp, and dumped into a crusher discharging directly to trucks. A pulverizer is in use to provide added fines for choking the top course. All material is dumped at point of use, then spread by hand.

Surfacing of the airport is a two-course, 2-in. asphaltic concrete pavement, semi-cold mix and cold laid. It is placed over the macadam base, which has been primed with 0.4 gal. per sq. yd. of bitumen applied by a pressure distributor. All surfacing material is purchased mixed and delivered on the runway and is spread by rented equipment. The bottom course material must pass a 1¼-in. screen and be retained on the ⅜-in. screen. The wearing course is limited to material passing a ⅜-in. screen but held on the No. 20 screen.

The project was expected to require 3 years to complete but excavation will be finished in 23 months. Available labor next year will be used for general improvement and beautifying of the port.

It is expected that major airlines will make daily stops and that air mail service will be available soon after completion of the work.

Cost of the Wheeling Airport is estimated at $1,784,000, of which $1,080,000 is available from WPA for labor, fuel, etc. The rest of the necessary money will come from the general fund of Ohio County, W. Va.

The state of West Virginia has completed about one third of the work on construction of a 127,000-yard grading job for an access highway .9 mile long.

Civic-minded sponsor of the project is Edw. W. Stifel, member of the State Board of Aeronautics, and the Board of Commissioners of the County of Ohio. Sidney Smith of C. C. Smith's Sons, consulting engineers of Wheeling, is in charge of design and construction. For WPA, E. C. Smith, Jr., is chief regional engineer, H. F. Kramer, director division of operations, and W. H. Ramp, area engineer. Albert Wessel of the Harrisburg, Pa., office, has represented the CAA.

Contractor for the excavation is Keeley Construction Co. of Clarksburg, W. Va., for whom J. C. Cain is in general charge.

Simple Shield Drives Sewer Tunnel

Peter J. Mascaro
Construction Engineer, Pittsburgh, Pa.

Contents in Brief—A shield of simple design was developed on a Pittsburgh sewer tunnel after hand methods were found to be too slow and expensive. The shield, nothing more than two ribs and a skin plate, is propelled by screw jacks and rides on carriages equipped with jack controls.

Ordinary Tunneling Methods proved too slow and expensive in driving 1,420-ft. length of tunnel for the Columbus Ave. relief sewer in Pittsburgh, Pa., so the contractor's superintendent developed a simple shield for the job that was so successful that he has patented its special features. The tunnel was part of the contract for 2,660 ft. of reinforced concrete sewer, 8 ft. 6 in. wide and 8 ft. 1½ in. high, finished dimensions, with an arched roof section, extending from the Ohio River to the Pennsylvania R. R. tracks, held by Ralph D. Thomas, of Pittsburgh. The remainder of the contract section was built in open cut.

The tunnel, in wet sandy clay and gravel soil with 20 to 33 ft. of cover, was started by hand methods; the ground support was pressed steel liner plates above the springline, wood lagging below, carried by steel ribs spaced the width of two rings of plate. However, the progress was so unsatisfactory that the contractor decided to build and try a special shield designed by his superintendent, Anthony Caputo.

Though in the first trial the shield buckled a little because of insufficient thickness of the skin plate, the progress was remarkable, especially as compared with that made by the hand methods. In three weeks prior to adoption of the shield the tunnel had advanced only 24 ft.; in 17 working days the shield crew drove 283 ft. of heading.

The progress of the shield was hampered by hand cart haulage of the muck. As this particular job was regarded as an experiment for the shield the contractor did not bother to install mechanical means for muck disposal, though he believes that a belt conveyor or some other faster disposal method would have speeded up driving operations.

The shield is of simple design, as can be seen from Fig. 2. It is built up of two 10-in. steel plate and angle ribs 4 ft. apart, braced near the bottom by I-beam cross-struts. The skin is two thicknesses of ¼-in. plate extending 3½ ft. behind the rear rib and 4 ft. in front, at the top, of the front rib as a hooded cutting edge. The tail is unsupported, and the tail plates, which drag on the primary lining, are loosely connected for flexibility in traveling around curves.

An unusual feature is a set of roller carriages, two on each side, framed into the lower end of the rib, upon which the shield rides. Rollers operate on either rail or plates, and are connected to the shield structure by vertical screw jacks. These jacks can check rolling of the shield and also aid in directional control.

Shield operation

The shield is propelled by four 2½-in. horizontal screw jacks, two on each side, framed into the front rib and extending through the rear rib. Provision is made for a fifth jack at the crown, shown in Fig. 2, but not installed on the Pittsburgh job.

The four shoving jacks are operated through worm gears and sprockets by an endless chain, one chain to the pair of jacks on each side. Thus, two jacks on one side are synchronized with each other but not with the pair

Fig. 1. Simple shield in Pittsburgh sewer tunnel operated by four screw jacks. This view was taken near the end of a shove; face breastboards are being placed. Note the air wrenches in the foreground for operating the shoving jacks.

on the opposite side. Air wrenches, acting through the lower sprockets, as shown in Fig. 1, operate the shoving jacks.

At the end of a shove, the jacks were retracted and a new lining rib set up against the back rib of the shield. Under the protection of the tail the two rings of plates were then bolted above springline to the old and new lining ribs and the wood lagging placed below the springline. The liner plates were stiff enough to take the thrust of the upper jacks without additional longitudinal stiffening, but timber struts were placed between the lining ribs to take the lower jack thrust.

Excavation was usually carried ahead of the cutting edge, but occasionally the shield would be pushed into unexcavated ground as a test. The four jacks prove adequate in such cases.

During the shove the two sides of the shield were constantly checked for directional control. At the end of a shove the face was lightly breasted and braced to the front rib of the shield while the smooth section of lining was erected. Each ring of the face was 16 in. wide, making a shove about 33 in. The tail overlapped the lining a minimum of 9 in.

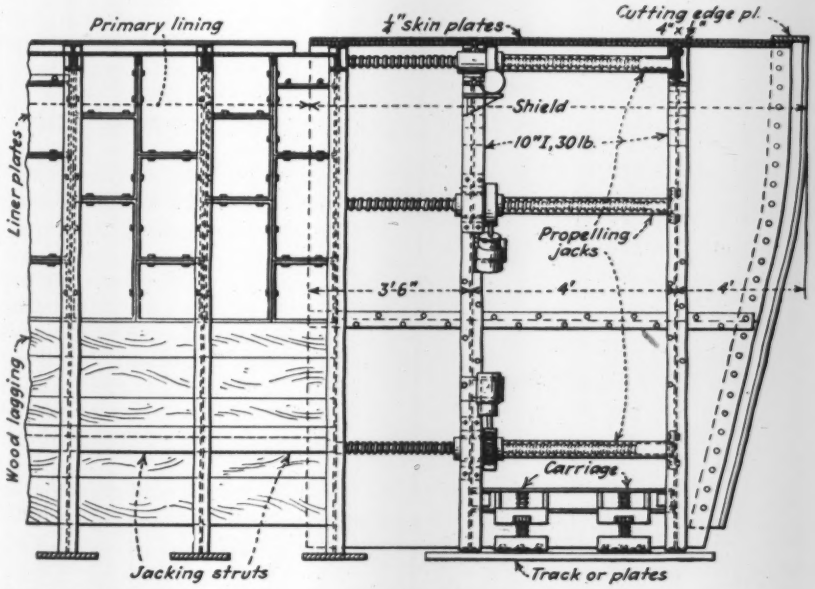


Fig. 2. Details of the shield and primary lining. Note unusual carriage arrangement for supporting the shield.

Direction

The sewer was built for the Bureau of Engineering, Department of Public Works, City of Pittsburgh. Frank M. Roessing is director of the department, John J. Croak is chief engineer of the bureau. Frank J. McCann was supervising engineer in charge of the project. Ralph D. Thomas, Pittsburgh, was contractor; Anthony Caputa designer and patentee of the shield, was superintendent.

Roof and supports as seen from reservoir floor; the columns are 24 ft. high.

Precast Supports and Girders Carry 4-Acre Reservoir Roof

PRECAST CONCRETE COLUMNS, girders and beams were selected recently at Ventura, Calif., in competition with other types of construction, for supporting a corrugated metal roof over a 4-acre reservoir in which the city stores filtered water. The reservoir itself, built in 1937, is a concrete-lined excavation with a capacity of 18.8 mg. It is of irregular shape, roughly 340x565 ft. in plan and about 18 ft. deep.

During the time when comparative studies were being made on redwood and precast concrete as materials for the roof framework, a disastrous fire in a wooden roof over a reservoir at Berkeley, Calif., swung the decision to precast concrete because of its noninflammable advantage.

As no live load had to be figured, it was decided not to provide any foundation under the 4-in. concrete paving on the reservoir floor. Instead, each roof column base is carried on a concrete pier 3 ft. square cast in place after a recess was first cut in the concrete paving to serve as an anchorage.

Because of the large area involved, the roof structure is divided into four units by two expansion joints at right angles to each other, running entirely across the reservoir. This design puts a double row of columns and beams entirely through the structure on each of these joints. Each column in the row that extends around the foot of the side slopes is braced against the slope so that all expansion movement is taken up along the central joints provided for that purpose.

Concrete specifications

There are 515 columns and a total of 9,688 lin.ft. of precast girders, 8,487 lin.ft. of precast struts and 36,224 lin.ft. of precast purlins. Details of connections at the column tops are shown in the accompanying drawing.

Specifications required the concrete in precast members to have a strength of 3,000 lb. per sq.in. before they were transported and erected. Using local aggregates with six sacks of cement per cubic yard of concrete, it was found that the 3,000-lb. strength requirement could be met on the fifth day and that by the 28th day test cylinders averaged 4,763 lb.

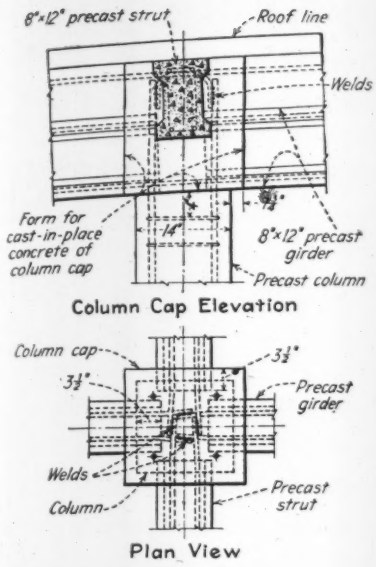
Erecting the columns

Columns were erected by a crane which set the dowel, projecting from the base of the column, in a hole provided for it in the socket cast in the top of the pier on which the column rests. From the top of the column reinforcing steel was left projecting to be welded, later, to steel bars extending from the ends of other precast members that meet on top of the columns.

Each column was plumbed with the aid of a plumb bob arranged to pivot around the top of the column and was then held in place by two braces until the precast girders and struts could be placed. Much time was saved in erecting girders and struts by providing temporary supports at the predetermined elevation in the form of steel angles bolted to the column caps on which the precast members could be landed by the erecting crane. When projecting steel in girders and braces had been welded, the joints were encased in concrete, poured in forms set up around and bolted to each column top.

Beams and purlins

Bridging and enough transverse beams to give the structure rigidity were poured in place first. These transverse beams, 8 in. in depth, were cast integral with the concrete poured over column tops to connect adjoin-



Details at column tops where precast members are bonded for rigidity.

ing girder ends. In the same pour purlins were also bonded into the column-top assembly. One continuity bar extends over the column in each stiffener girder.

All purlins have a 2x3-in. redwood strip on the upper edge, held in place in the concrete with galvanized nails. These strips, which were set in position as the purlins were being cast in the vibrating machine, serve as nailing pieces for the galvanized metal roofing.

Roof ventilation

The roof has a central louvre raised above the main roof level for the entire length of the reservoir. A natural circulation of air is set up by thermal induction between this central louvre and openings around the outer edge. All openings are screened with ¼-in. mesh monel screening on redwood framing.

Bracing for the superstructure of the louvre as well as for diagonals extending from columns to the sidewalls of the reservoir, necessitated angular connections between columns and braces. A few of the columns have as many as five intersecting members at the same level. At all these connections the reinforcing is welded and later encased in concrete poured around the steel.

After completion, the entire exterior surface was given a spray coat of gray cement primer paint followed by a spray coat of aluminum in a bituminous vehicle.

Design for the roof structure was made under the supervision of Carl Froerer, city engineer; Richard Valentine was structural engineer and Walter S. Swan, resident engineer inspector. Major Wm. W. Post represented the PWA. H. B. Nicholson held the general contract. Some of the precast members were made by Graham Bros., Los Angeles.

Abnormal Rainfall in Texas

RAINFALL that totaled as much as 20 in. in a 36-hr. period in a small section of the Lower Colorado River valley in Texas swept over part of the basin of that river and the Lavaca, Guadalupe and Brazos rivers on June 29-30. The extent and intensity of the rainfall is shown in the accompanying drawing. This storm had the highest intensity and was of longer duration than any large storm of record in the Colorado River valley, though there have been small storms of greater local intensity.

Notable is the fact that the area of greatest intensity, centering around Smithville, was in the narrow part of the Colorado River valley and below the dams built by the Colorado River Authority. (See *ENR*, June 6, 1940, p. 794, for map showing whole river basin.)

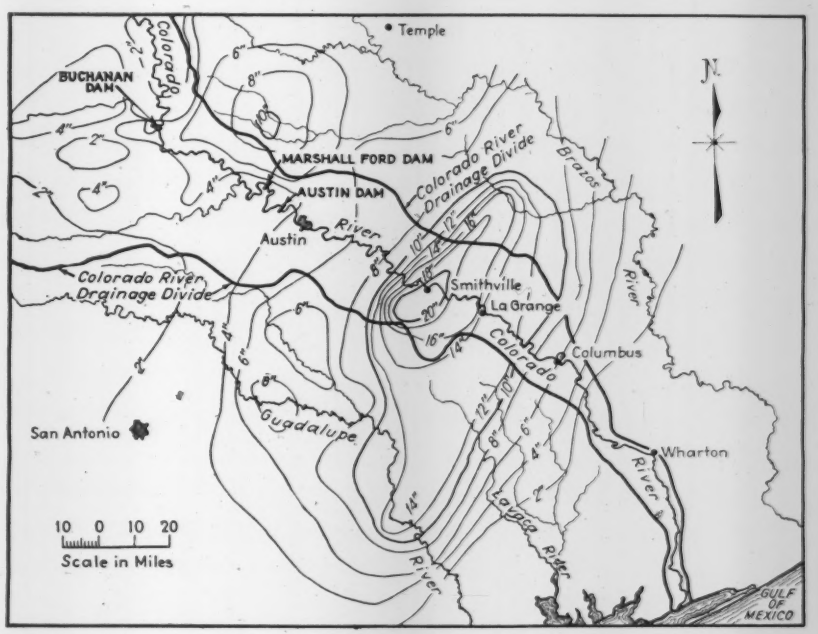
The accompanying isohetal map of the region subject to the storm shows the rainfall based on about 100 points of known and accurately measured rainfall. No recording gages are located in the regions of maximum rainfall, hence no record of maximum intensities is available.

The accompanying table, prepared from data obtained from the U.S. Geological Survey, gives the peak discharges at Austin and below. The normal low stage for all the points given is about 2 ft.

This information was obtained from the Lower Colorado River Authority, Clarence McDonough, general manager, and C. S. Adams, designing engineer.

PEAK DISCHARGES OF THE COLORADO RIVER IN TEXAS DURING FLOOD OF JUNE 29-30, 1940

Town	Peak Stage in feet	Peak Discharge in c.f.s.	Time	Date
Austin.....	17.5	47,000	11:30 A. M.	June 30
Smithville..	21.0	70,000	4:00 P.M.	June 30
LaGrange..	40.2	200,000	8:30 P.M.	June 30
Columbus..	36.3	140,000	3:00 P.M.	July 1
Wharton...	36.0	110,000	4:00 A.M.	July 3



Isohetal map showing rainfall concentrations in the lower valley of the Colorado River and adjoining streams in Texas, June 29-30. This rain fell in a 36-hr. period.

Design Factors for Dual Disposal

***Contents in Brief**—Combined disposal of sewage and garbage is still in the pioneering stage, said Louis R. Howson, consulting engineer, and it is desirable to provide "factors of ignorance" in the design of dual disposal plants. What was done at the Gary, Ind., installation, designed by Alvord, Burdick and Howson, was discussed by Mr. Howson at the Federation of Sewage Works Association's meeting. His comments were as follows:*

DUAL DISPOSAL of sewage and garbage, like all other engineering problems, ultimately simmers down to a consideration of economics. There is no method or combination of methods of municipal waste treatment generally applicable to all conditions. Each decision, therefore, must be based upon a careful analysis of the requirements and a comparative study of the various practicable means of meeting them, each estimated as to cost, and all evaluated on a common basis of accomplishment and annual cost.

Applying this reasoning to the situation at Gary, Ind., the following conditions were found to favor the adoption of dual disposal facilities:

The city already had an incinerator capable of handling all of the rubbish but entirely inadequate to handle garbage with the rubbish.

Dual disposal made it possible to utilize the existing incinerator for rubbish. With any other means of disposal it would have been necessary to have scrapped the existing incinerator.

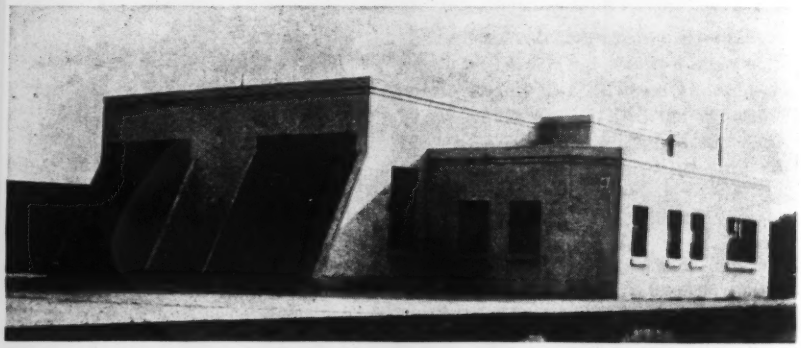
Dual disposal when credited with the value of the additional by-product gas available for power was about $12,000 per year lower in annual cost than incineration with heat recovery, and approximately $10,000 per year cheaper than incineration alone. In first cost grinding and digestion was only about one-half as costly as incineration with heat recovery.

Admittedly dual disposal on a municipal plant scale is still more or less in the pioneering stage. As such, it should be recognized that the early installations will be modified as time passes and a greater background of experience is available for guidance.

One of the best means of avoiding pitfalls in pioneer work is to design liberally; just as with activated sludge early designs provided in excess of 1 cu.ft. of air per gallon for ordinary strength sewages and have since demonstrated the ability to operate satisfactorily at from 0.4 to 0.7 cu.ft. per gallon, and just as with trickling filters the early loadings of B.O.D. per acre-foot were very materially lower than those now known to be practicable, so is it desirable to provide liberal factors of safety or, if you please, factors of ignorance in the design of dual disposal systems at this time.

For illustration, sludge digestion capacity at Gary has been provided in the amount of approximately 9 cu.ft. per capita based on the present population, and 6 cu.ft. per capita based on the design population; this capacity is materially greater than that used in earlier plants where some digestion difficulties have been experienced. In determining the digester capacity for dual disposal the designer must provide for the extreme fluctuations in garbage solids which reach a maximum during the cantaloupe, sweetcorn, and watermelon season. The ratio of peak to average monthly solids may be twice as great with garbage as sewage and this must necessarily be reflected in digester capacity.

Similarly, the area of the digestion tanks has been made large and the depth relatively shallow in order to minimize the effect of violent gassing. At Gary the surface area of the digesters is over 50,000 sq.ft. At 2½ cu.ft. of gas per capita the amount of gas collected per square foot of tank will be but 6 cu.ft. per 24 hours. It is hoped that this liberal area will reduce the trouble experienced elsewhere due to "boiling" and the re-



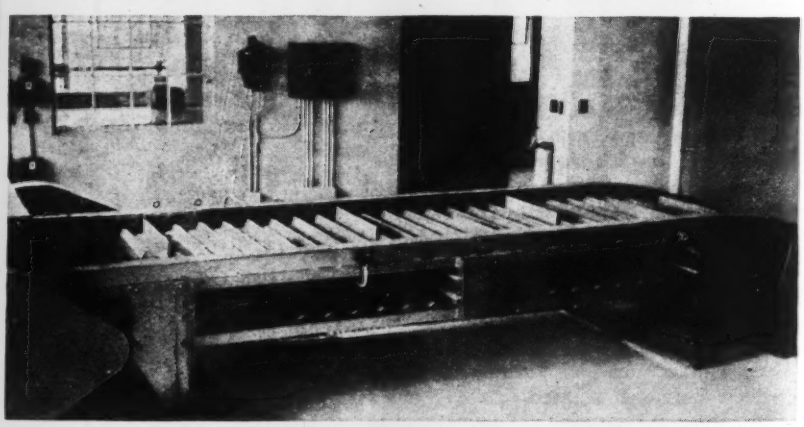


Fig. 1. Garbage dumping pits, steel picking belts and grinding facilities are housed in the building shown at the top, which is located at the entrance to the treatment works. The lower picture shows one of the picking belts; in carrying the garbage from a pit to the grinders it affords opportunity to remove undesirable materials such as bones, bottles and metalware.

sulting excessive solids in the supernatant liquor.

It is further the writer's opinion that the provision of duplicate or multiple facilities is more than usually essential in pioneer installations. At Gary there are two garbage grinders, five sewage comminutors, two mechanically-cleaned grit chambers, four clarifiers, and eight digesters. (*ENR*, Aug. 29, 1940, p. 273).

Based upon the observation of experience elsewhere, it is believed particularly important with garbage grinding to employ grit removal facilities prior to passage of the sewage and garbage to parts of the plant where there are restricted pipe openings. The easiest way to accomplish this is to locate the grinder along the sewer above the treatment plant. At Gary the garbage grinding installation is located on the sewage treatment plant site immediately adjoining the main intercepter and about 300 ft. upstream from the comminutors.

In providing air equipment the Gary installation is also very liberal. There are three electric-motor-driven centrifugal units and two gas-engine-driven displacement units in sizes such that deliveries of 5, 7, 9, 12, 14, 16, 19, 21, 26, 28, 30, and 35 thousand cubic feet of air per minute are practicable. Up to 14,000 cu.ft. of this capacity can be supplied by the gas-engine-driven units. The total capacity is equivalent to 1.25 cu.ft. of air per gallon of sewage on the design basis of which 0.5 cu.ft. of air per gallon is provided by gas-engine-driven units. This relatively large air installation is to permit as great utilization of the gas as possible and at the same time protect against the contingency of complete electric operation if necessary. Gas storage of 200,000 cu.ft. is provided to equalize variations in gas production rates due to irregular addition of garbage solids. It is estimated that the increased use of air due to the addition of garbage solids will be about 15 per cent.

The 40-mgd activated sludge plant at Gary will handle the entire output of garbage from the city, estimated to be from 30 to 35 tons per day.

Dual disposal, concluded Mr. Howson, is now beginning to speak for itself through operating records and eventually there will emerge more definite limits of its economic practicability.

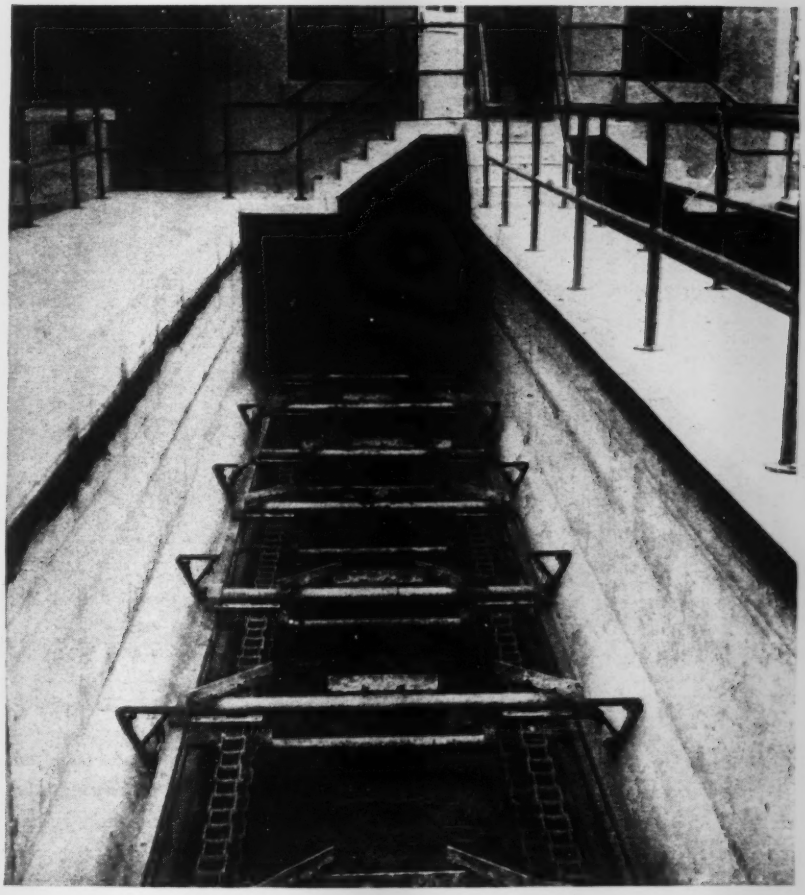


Fig. 2. Grit removal chamber. The slow-moving metal scrapers move the grit to the influent end of the tank where a screw conveyor elevates the material to dump into cars operating on a narrow-gage railway. There are two chambers for alternate use at Gary.

Fig. 3. Tube diffusers for aerating the activated sludge mixture.

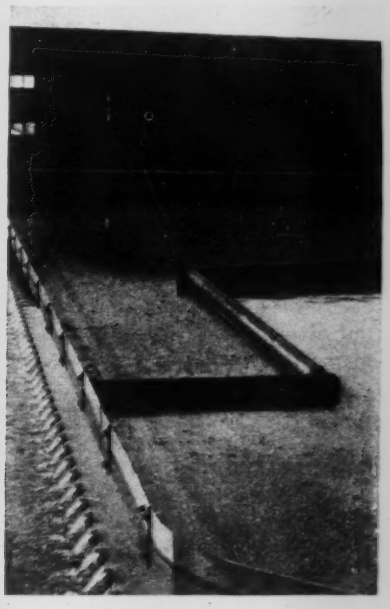


Fig. 4. Grease skimmer of new design on the primary settling tanks.

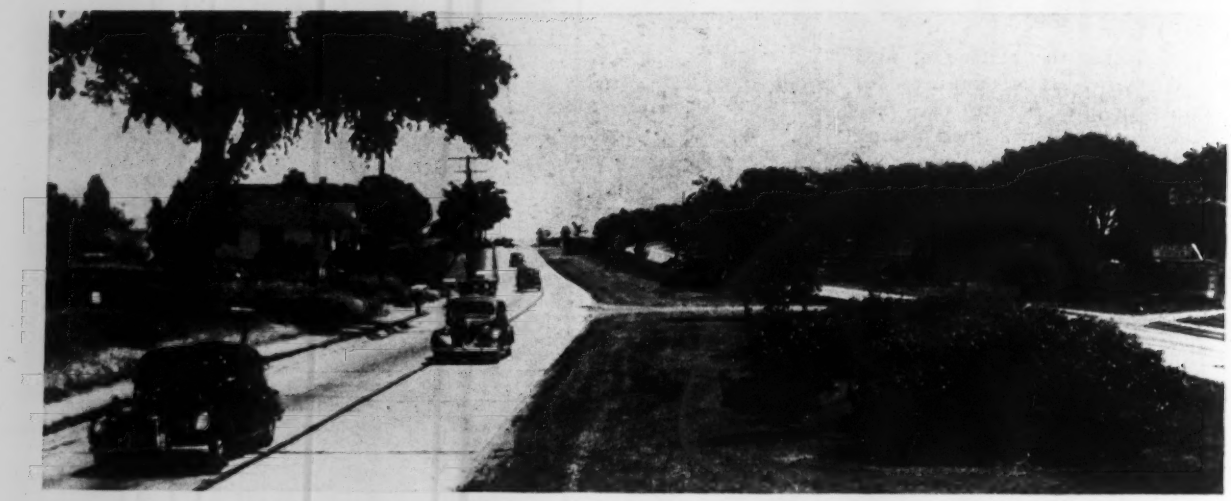


Fig. 1. Crowned roadways on a Wisconsin highway drain to a dished median strip.

Runoff Disposal on Divided Highways

***Contents in Brief**—A complex design problem faces the road engineer in disposing of runoff on divided highways. Varying cross-profiles change the direction and volumes of water shed to edges and center and require various forms of water-collecting structures. A wide range of suggestive structure designs is given in a survey of practice in a dozen leading road-building states.*

THE DIVIDED HIGHWAY presents a special design problem in handling surface runoff. How is it being solved? Some of the answers are given in the observations that follow, which are based on visits during the past twelve months to divided roads under construction or recently built in active roadbuilding states and on comment by state highway engineers. Supplemented by drawings, these observations provide a cross-section of a surface-drainage practice that is developing in conformity to the fundamental theory that methods are determined by the required design of the divided road. Cross-profile and dimensions for the road are controlling factors.

In present divided highway practice, standards prevail only in a general way whether in cross-profile or in median strip width and structure. Design is individual, depending on location, right-of-way, topography, the salvaging of existing roads and many other conditions. This also is the case in the special detail of surface drainage that is considered here: design and structures vary with the manner in which the paved roadway is crowned, the width and character of shoulders and the type of median strip—that is, whether it is planted or is curbed and paved and whether it is raised, depressed or sloped.

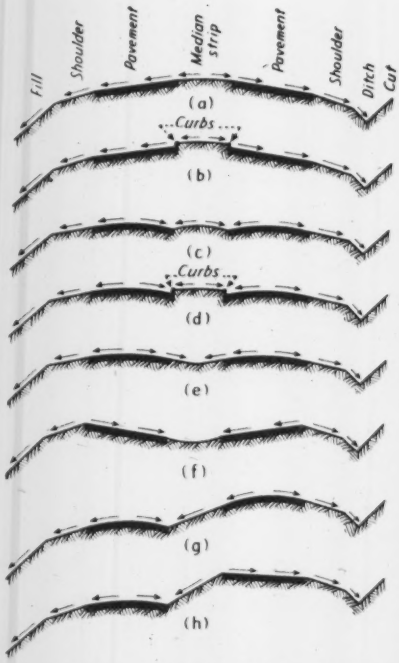


Fig. 2. Types of cross-profiles showing various directions of transverse runoff to be considered in draining a divided highway.

The problem presented

The amount of runoff is the most important basic factor to be considered. On a modern divided road, say one of the section now being built in Connecticut, having a 21-ft. median strip separating two 23-ft. pavements flanked by 7½-ft. shoulders, the runoff area is nearly 10 acres per mile. Assuming that the median strip is grassed and absorbs all the rain that falls directly on it, then something over seven acres are virtually impervious surface, (pavement and shoulders) from which the rain drains fully and rapidly. The count of quantities can easily be extended, but enough is said to indicate the considerable factor of rainfall disposal in divided highway design. And rainfall is not all. In northern states where snow is common, snow water adds a second major factor. Ordinarily the volume of water from melting snow calls for drainage structures of no greater capacity than is required for rainfall, but snow presents problems that rainfall does not. In the almost universal

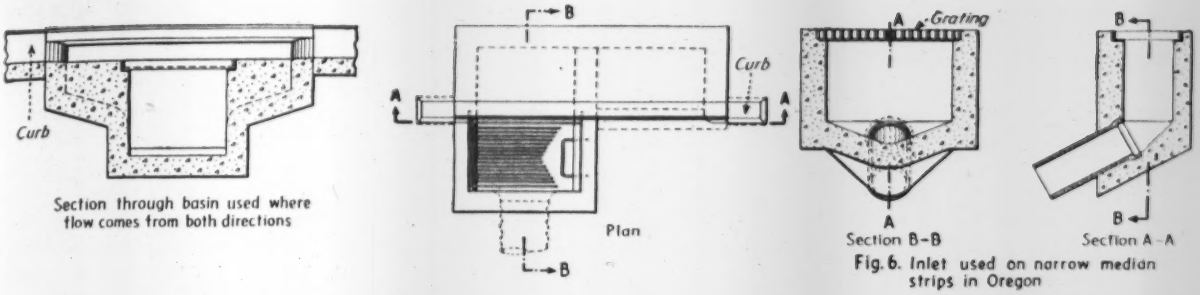
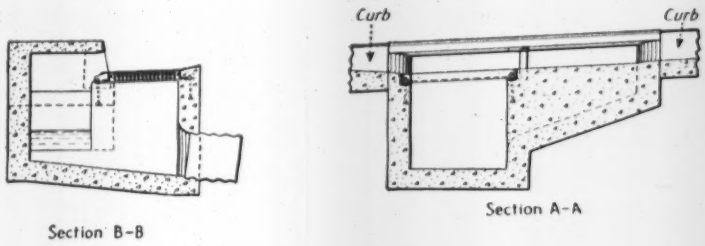


Fig. 6. Inlet used on narrow median strips in Oregon



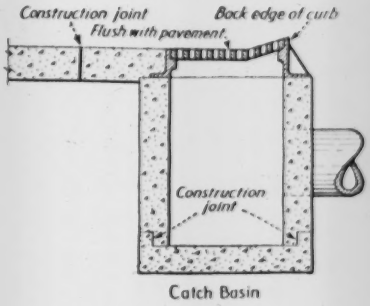


Fig. 3. Inlets and catch basins in California are standardized as to structural type but dimensions vary

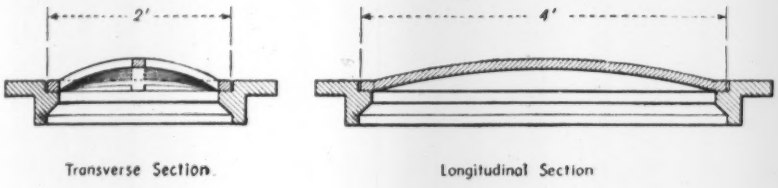


Fig. 4. Domed grating used for catch-basin tops in Indiana

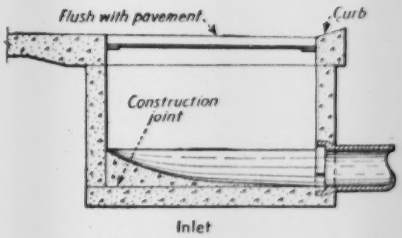


Fig. 7. Drainage structure used with lip curbs in Ohio

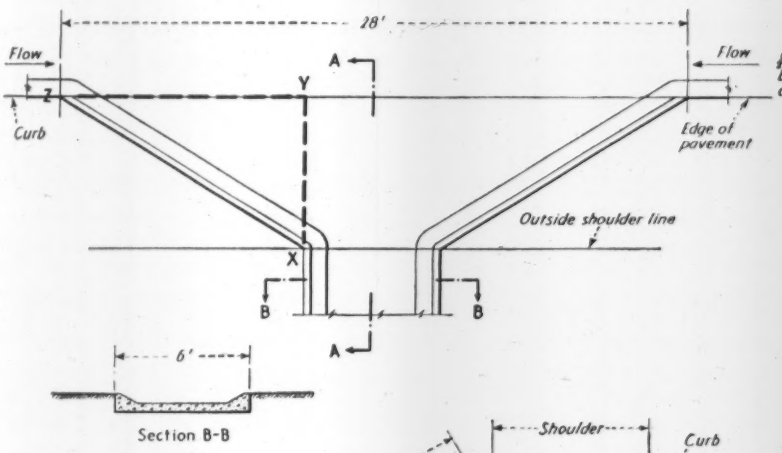


Fig. 5. Spillways through lip curbs are used in Louisiana to divert water down fill slopes. This design takes flow from two directions. For flow from one direction the curb follows the line X Y Z

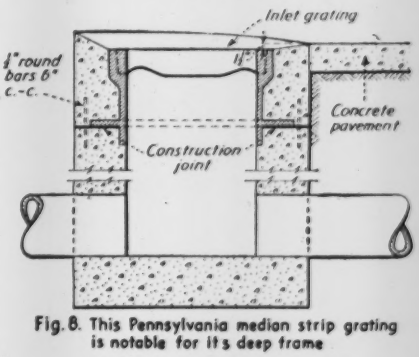


Fig. 8. This Pennsylvania median strip grating is notable for its deep frame

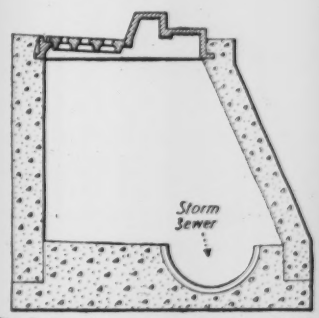


Fig. 9. New Jersey uses this type of inlet to storm sewer parallel to the road

Figs. 3-9. Types of catch basins and inlet structures used on divided roads in various parts of the country.

practice of snow removal for winter traffic, the snow plowed from the pavement is stored on the shoulders and on the median strip if it is at all wide. The piled snow blocks free runoff; as it melts from the top, obstruction continues until the last of the snow. If the thaw is continuous, there is a wet pavement and if day thawing and night freezing alternate, there are alternate water and ice. During thawing a concentration of wet conditions at the pavement edges may soften subgrade or even cause frost heaves. Altogether, melting snow may be a more important factor in the surface drainage of divided highways than is falling rain. In many highway departments it is regarded as the most serious factor.

Then finally there is the bearing of cross-profile on runoff direction and intensity, and of cuts and fills and grades on places of disposal. Engineering and economic influences that supersede drainage determine these elements of road structure. Fig. 2 shows the variety of cross-profiles that will be observed in any considerable range of travel; the arrows indicate the runoff slopes. Disposal is in various proportions over shoulder and to the center where collecting structures and longitudinal conduits take the water to places, generally low points in the longitudinal profile, where it can be discharged safely outside the roadway zone. The forms of these structures are many and only examples can be illustrated to indicate variety and purpose; these are taken from practice in some half-score states from California across-country to the Atlantic coast.

On the Pacific Coast

On the Pacific Coast California has the greatest concentration of divided highways and a variety of topography and climate to influence practice. A California catchbasin is shown by Fig. 3 and Fig. 6 shows one in Oregon; these indicate variety required in a single type of drainage structure. Variety is equally apparent in the broader drainage design practices. In brief, runoff is not handled in a standard way, but to meet the individual road conditions and drainage requirements.

Except where superelevation controls the slope, the usual California practice is to slope the two pavements away from the median strip. The degree of slope depends on the type of pavement; steeper slopes are used for the lower types of surfacing than for high type pavement; always the slope is held to the minimum necessary to assure adequate runoff.

It is believed that pavements sloped away from the median strip minimize need for special structures for surface drainage. In case the median strip is narrow and not adaptable to planting it generally has an impervious surface treatment and invariably it is raised whether bordered by curbs or constructed as a rolled-earth area between pavements. The runoff conditions are then substantially those of an undivided road and the problem of surface drainage is the same. The problem is also much the same when the median strip is wide but is raised and curbed, provided the separated roadways are constructed at the same level. Variation arises only through planting.

Wherever practicable, wide median strips are generally planted, and this brings in the problem of possible separate drainage for the median strip. Unsurfaced strips are subject to precipitation falling directly on them and to any extra irrigation required for plant maintenance. Then excess moisture has to be cared for by subdrainage where the excess may be detrimental to the subgrade of the adjacent pavement. Perforated pipe or pervious layers within the median strip may be required with relief structures passing excess water laterally across one of the roadways. If the center of the median strips is depressed to facilitate the collection of the water then the subgrade for adjacent pavements must be constructed of a material and in a manner that it will not be weakened by water. Where the dividing strip is depressed, central drainage is facilitated but sometimes outlets are difficult to secure where the grade line is not raised appreciably above adjacent level lands.

Drainage is required when the runoff is to the sides of the road over the shoulder. In California practice, roads of divided-highway importance are held to justify wide shoulders and these shoulders are treated so that they are protected from surface runoff. The method of discharge over the side of the embankment depends upon the probability of slope erosion. On low embankments, where slopes are flat, natural vegetation protects amply against erosion but on high embankments or on appreciable roadway gradients, a raised treated-earth dike along the edge of the shoulder, supplemented where necessary by gutters, carries drainage longitudinally to spillways down the slopes. Side ditches similarly care for side drainage in cuts.

The raised treated-earth dike along the edge of shoulders in California has proved a good and economical means of controlling drainage originating on roadways. As used on the outside edges, it functions for any type of roadway. It can be similarly used on the inside edge of the higher lanes of a divided roadway having a slope between the two roadways (Fig. 14). Such slopes are not commonly treated by means detrimental to planting or natural growth and must have protection from erosion. Spillways at intervals along the raised dikes pass lateral drainage at appropriate locations and prevent rutting of shoulders and side slopes. But raised dikes are not considered desirable where not positively required—i.e., where flat slopes are practicable.

In numerous instances in California, divided highways are being constructed with a new roadway separated from an existing pavement by a median strip 30 ft. wide. The new roadway may or may not be at the same level as the existing roadway and often conditions warrant the separation in grade. Where material separation occasions a sloped median strip between the two roadways, drainage within the area between the pavements may be carried down the slope to a gutter parallel to the inside edge of the lower pavement. In developing an existing two-lane road to a divided road, more often than not, the old pavement is the low one and it is crowned for half its width toward the median strip. Then the gutters are not located immediately adjacent to the pavement but outside of a narrow shoulder area. Drainage is carried along the median strip to an outlet to one of the regular cross-drains, or, where warranted, separate relief drains are provided through drop inlets. In some instances the inside edge of the low roadway is curbed to restrain water and drift coming from the high road. Occasionally ditches within the dividing strip may be deep enough to carry water longer distances as well as through cross-drains placed under cross-overs in the dividing strips.

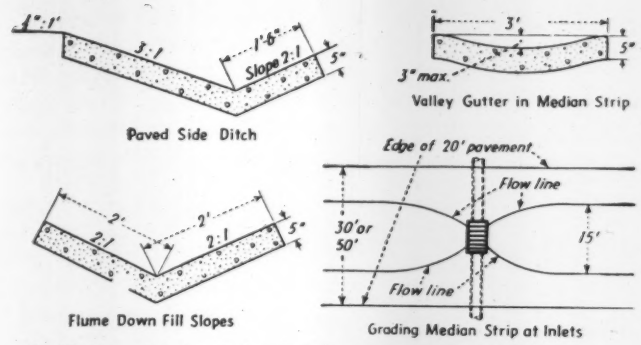


Fig 10. Form of gutter, ditch and flume sections used on Maryland roads

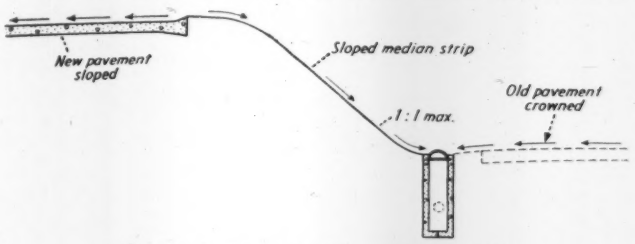


Fig. 11. Method of handling runoff from roads at two levels as used in Ohio

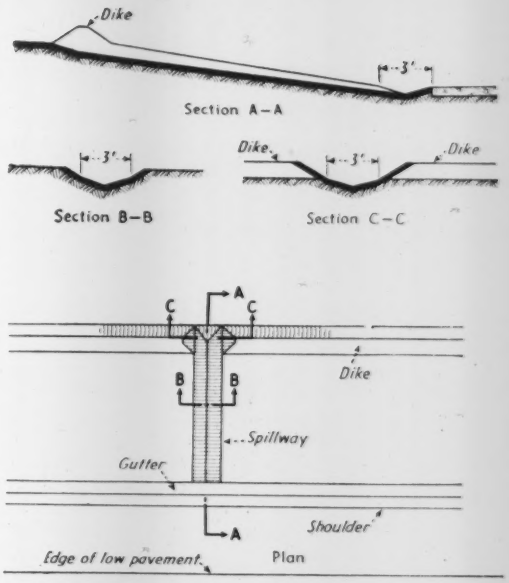


Fig. 14. In California dikes are used on the high road to lead runoff to spillways to ditches on the lower road

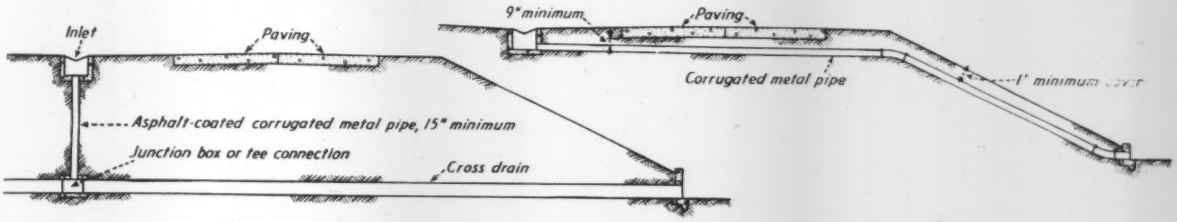


Fig. 12. Two types of underdrains are used in Maryland to serve catchbasins in median strips

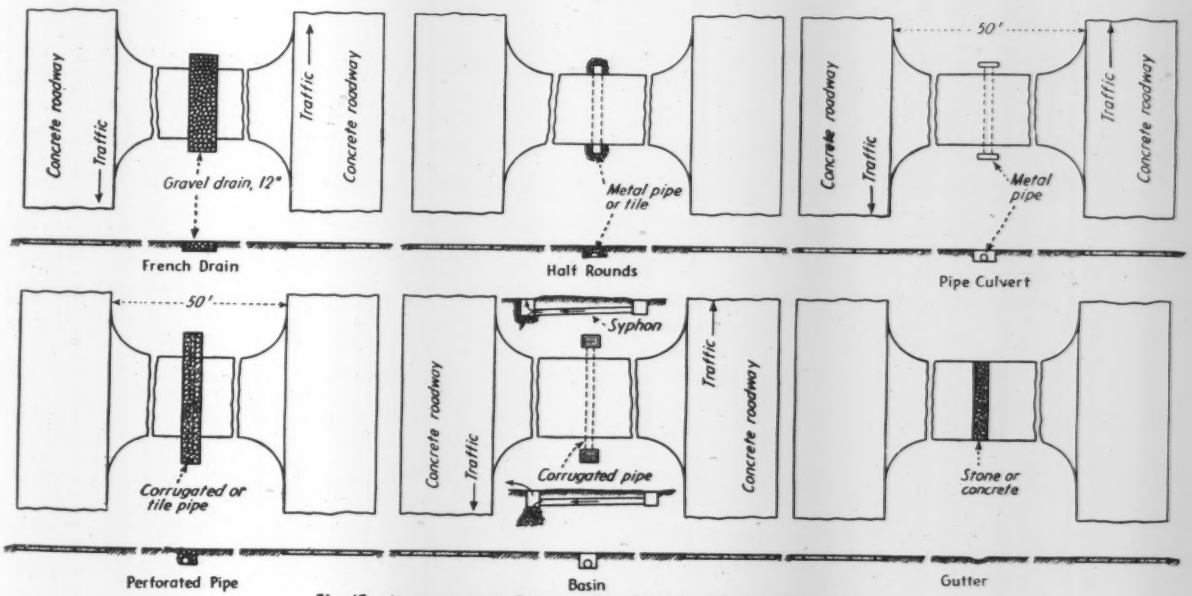


Fig. 13. At crossovers in Delaware, flow along the dished median strip is carried by underdrains of the various kinds here shown

Figs. 10-14. Cross-drains and ditches of several types are used on divided roads to suit local conditions of climate, soil or topography. They show that considerable thought is being devoted to building into the roadway a refinement of detail that will pay large dividends in reduced maintenance.

Superelevation on curves of course interrupts the usual cross-profile that slopes each way from the median strip. Where median strips are curbed the surface runoff on superelevated cross-profiles is controlled by the central curb and gutter. Unless careful design of the grade line cannot advantageously lead side drainage to natural relief points to dispose of water on the low side of superelevated curbs, catchbasins or drop inlets at the curb line or within the dividing strip are constructed as entrances to cross-drains to one side of the roadway. Small openings in the dividing curb at times will pass water across the median strip, provided dispersion is in small amounts where rainfall is light.

In the central states

Proceeding east, no considerable adoption of divided highways is found until the Mississippi River is crossed. Illinois, Indiana and Ohio give a fair cross-section of drainage practice, with mention of special structures from some other states.

In Illinois where the width of median strip is less than 30 ft., surface runoff is carried to the outside. Where it is greater than 30 ft., each pavement is given a normal crown and surface water is carried to both sides. With this latter design, the water in the median strip ditch is carried by drop inlets to either culverts or pipelines. Indiana has 20 and 22-ft. pavements with 4, 15, 20, 30, 40 and 44-ft. median strips; generally the 4-ft. widths are curbed and paved, the 15 and 20-ft. widths are crowned earth and the 30 to 44-ft. widths are dished. A type of domed grating used on inlets is shown by Fig. 4. Ohio, with its large proportion of surfaced roads, is developing many divided highways by adding a dividing strip and a two-lane pavement parallel to an existing pavement. Where the existing pavement is at a lower level than the other, a common drainage arrangement is shown by Fig. 11. In the past, new pavement has been drained to the outside edges but this is found to keep the entire surface of the pavement wet for longer periods of time and now the trend of design is to crown each unit and provide drainage in the median strip for half of each unit of lanes. Typical inlet structures are shown by Fig. 7.

Distinctly divided-road design has not been extensive in Pennsylvania

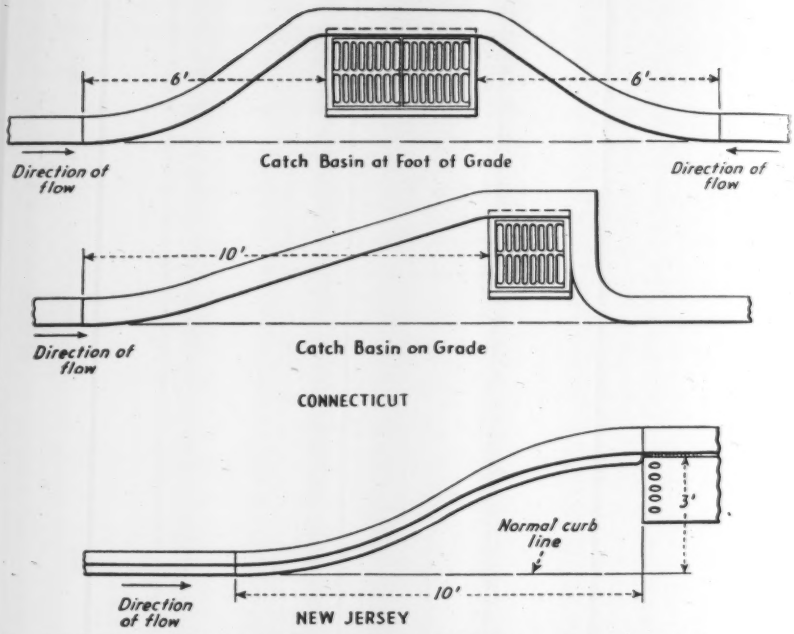


Fig. 15. Coving of the curb to place the catchbasin grating outside the travel lane as practiced in Connecticut and New Jersey.

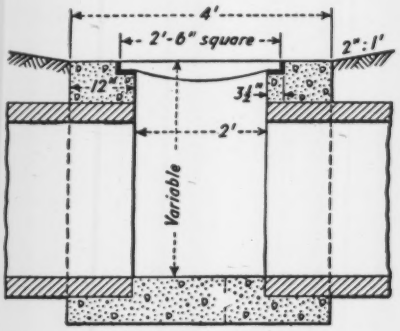


Fig. 16. Catchbasin used in Virginia for dished median strips.

but it is apparent in a four-lane road now being built north from Harrisburg; each half is independently crowned and runoff to the 5-ft. bituminous median strip is taken by catchbasins in the median strip and of the unusual construction shown by Fig. 8. The Pennsylvania Turnpike drains both ways from the 10-ft. median strip with a slope of ¼ in. for the inside 12-ft. lane and 1¾ in. for the outside lane. No curbs are used and the drainage flows over the paved 10-ft. shoulder to a flush inlet at the ditch line.

Along the Atlantic Coast

Unless California may be excepted, the greatest concentration of divided roads is in the states along the Atlantic Coast. Their practice presents surface drainage methods and thinking in all varieties, but with general agreement that design and plan are not reducible to standards. This belief is found particularly in Connecticut, which, in the Merritt Parkway planned perhaps the first well considered set of structures for divided highway runoff.

Ways of handling surface water, the Connecticut engineers point out, vary greatly with the type, design and location of the road; a method which may prove satisfactory where snow is not common may be very objectionable where snow is common and plentiful. Even in this state's own road department are found very different opinions commonly based on whether the person is connected with construction or maintenance. The outstanding example of divided highways in Connecticut is the Merritt Parkway; it has two 26-ft. roadways separated by a 21-ft. median strip crowned and planted and having both median-strip and shoulder curbs. Each roadway is separately crowned 2¼ in. Drainage is to catchbasins set in coves in the curbs (Fig. 15) and then to an underground drainage system in the median strip.

This plan has proved fairly satisfactory except on superelevated curves; here melting snow on the median strip drains across the pavement and freezes. In some cases this condition has been overcome by a shallow ditch in the median strip to hold the snow water from reaching

the pavement. This resort has been quite satisfactory in respect to maintenance but it is believed that in some cases it tends to permit water to seep under the pavement edge and introduce danger of frost heaves. Merritt Parkway was an earlier and rather special design; except on the Parkway present design keeps the same crowned 21-ft. 2-in. median strip, has median strip curbs, has 23-ft. pavements, omits shoulder curbs and has 7-ft. 5-in. stabilized shoulders. Each pavement is crowned separately; the outside slopes drain across the shoulders and the inside slopes and the median strip to recessed inlets in the median strip curbs. The inlets lead to the drainage system in the median strip or across road to the toes of slopes. In a few cases designers have experimented with carrying the water in grass ditches in the median-strip area; while this has proved to be fairly satisfactory on flat grades it is not recommended where the grades are more than 2 or 3 per cent because of scour in the ditch.

Early practice in New Jersey was to crown both roadways at the center of the median strip and drain both ways to the shoulders. Soon it was found that in many cases the water was enough to require longitudinal storm sewers (Fig. 9) and some had to be installed after the road had been constructed so that now they are built when the road is built. In such case the two roadways are crowned independently giving flow in four ways. This is an advantage in handling snow water. Recently, to provide clear roadway width, the curb has been recessed for catchbasins and curb inlets, as illustrated in Fig. 15.

In Delaware the handling of drainage depends on the width of the median strip. Up to 20 ft., surface drainage is usually carried from the edge of the strip across the pavement to the ditch or curb, then to existing catchbasins, or in an urban district, stormwater sewers are built to take care of the water. These are usually placed under the curb line and, in some instances, in the parkway area.

On parkways 50 to 70 ft. wide, each roadway sheds water to the median strip and to the shoulder. On these, the drainage is carried to the middle of the median strip and if the grade is sufficient, is carried along it to catchbasins placed over pipes crossing the road or to culverts and bridges. Usually, for the last 15 ft. or so, a concrete gutter has been placed to prevent scour. Where grades are flat on wide separations, and where it is difficult to drain, a stormwater sewer with a grade independent of the road grade is built to some outlet, usually a pipe or culvert crossing the roadways.

On rural sections median strips are not curbed; sod comes up to edge of pavement. Objection to curbs, even the low lip type, is that they psychologically narrow the passing lane and prevent full removal of snow to the pavement edge which causes ponding and ice trouble. These are not fully escaped with flush parkway edges; dirt from the pavement washes to the parkway edge and the extra moisture encourages better grass growth and the two build up a ridge that obstructs free flow onto the parkway. It is therefore an occasional maintenance task to blade down these ridges and reseed the scraped part. Where curbs are used they are solid white cement concrete.

A special problem is cross-drainage of the median strip at turnouts or intersections. Various Delaware practices are shown by Fig. 13.

In Maryland transverse profile has varied. On the Philadelphia road, the Public Roads Administration required each pair of lanes to slope to the median strip, the idea being to keep drainage from softening the shoulders. The flat slope gave very sluggish runoff to the median strip, with the result that water stands on the surface on level grades. Again, in snow removal, snow plowed to the median strip blocks lip-curb flow and ponds water as the snow melts—so that it flows across the road and gives icy conditions in freezing weather. On swamp fills on this road the cross-profile was changed to slope the pavements to the shoulders; the idea was to keep drainage from softening the center of the fill. Melting snow piled in the median strip drained across the pavement and again ice resulted. The feeling is that the flat slope to center is out definitely. A 30-ft. separating strip is desired on 150-ft. right-of-way; on narrow road it is forced down to 6 ft. but 10 ft. is the desired minimum. Median strips are dished, grassed, have valley gutters to catchbasins and under-pavement drains to the outside. Fig. 12 shows two under-pavement drain arrangements and Fig. 10 shows various surface drain details.

In regard to handling surface runoff, the earliest development of divided highway in Virginia provided for a raised grass plot between two pavements with slopes running in each direction from the center of the grass plot. The result of this type of design is that all surface water must drain from the grass plot and then cross the pavement. In areas where freezing conditions are frequently encountered, this provides the possibility of having the pavements covered with a sheet of ice during wet weather and freezing temperatures. It is also true that on such divided highways the center plot is frequently used for storage of snow and, again, when this snow melts it runs across the pavement and freezes when the temperature drops low enough.

Therefore, in Virginia it is decided to adopt, wherever possible, a depressed center median strip, with each pavement crowned at the center of the pavement and draining both ways, in one case into the depressed grass plot and in the other case into the side ditches. The water collected in the depressed section is carried to drop inlets (Fig. 16) and discharged under the pavement.

Cost Records For Tractor Service

To enable the owner of a tractor or stationary power unit to obtain readily a simple but sufficiently complete statistical record of its performance, the International Harvester Co., Chicago, Ill., has developed a daily report form for the operator and a cost-record book for the office. In this latter, the daily information is entered in tabular form, then summarized for each month and finally analyzed for the year.

The operator's daily report, is a paper slip 6¼x4¼ in., put up in convenient pads. The book, with a page for each month, and a line for each day, is 11x8½ in., or letter size. It is ruled in vertical columns for operating data (hours worked, idle and in shop, miles traveled or number of work units), and for daily expenses (fuel, oil, grease and repairs). These columns are totaled on the bottom line for the month. The last table recapitulates the monthly figures and gives the yearly total. One cost-record book is required for each tractor or stationary machine.

Housing Kentucky Dam Workers

E. S. Draper
Formerly Director Regional Planning Studies, TVA, Knoxville, Tenn.

***Contents in Brief**—TVA engineers draw on experience in building five construction camps to perfect design of workmen's dormitories for Kentucky Dam. A U-shaped, one-story, sixty-man dormitory with sanitary and service facilities in the yoke end was found superior. Central heating and forced ventilation improves the health and energy of the workmen.*

THE EVOLUTION of a bunkhouse throughout the building of one after another of the six TVA dams is shown in its latest stage by the workmen's dormitories at Kentucky Dam. In these structures practice has come to a U-plan, a single story, accommodations for 60 men only, central heat and forced ventilation. These features embody, it is believed, the most advanced standards developed over a period of nearly seven years' experience in the operation of large construction camps.

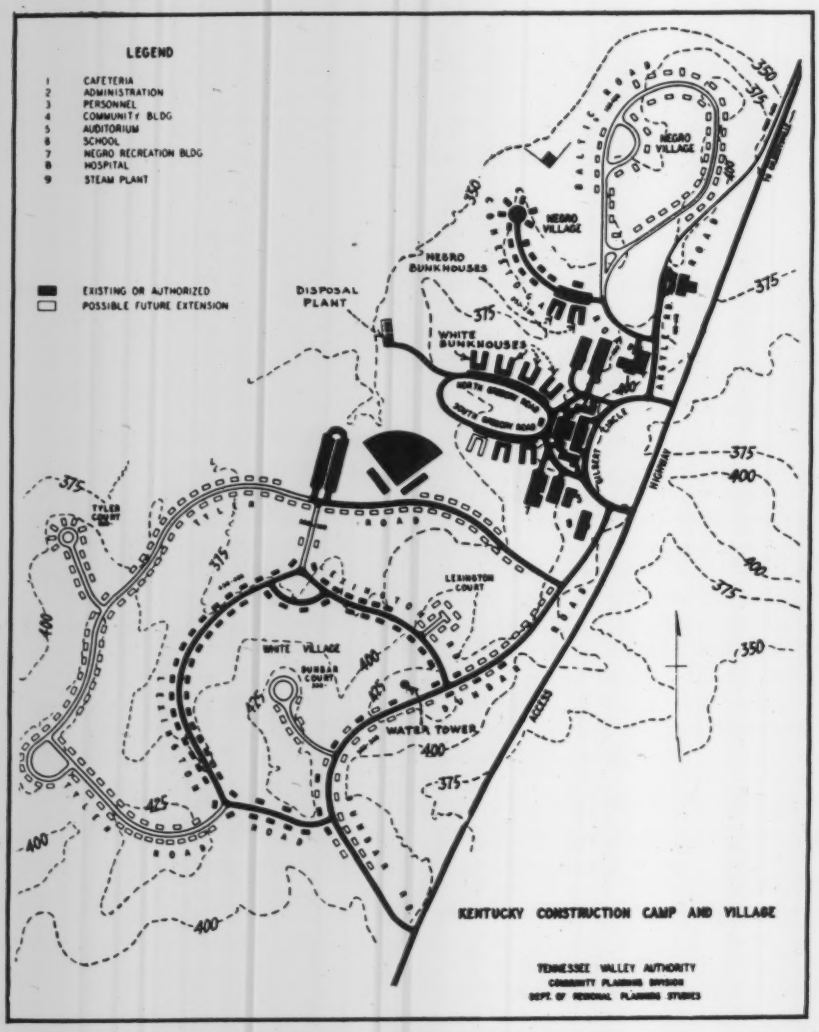


Fig. 1. Camp plans are drawn to provide for the fullest possible extension of housing that may be called for if the planned six-year construction period at Kentucky Dam is shortened by increasing the working force.

A distinctive housing plan

Kentucky Dam is the latest of the TVA dams to be placed under construction and as construction is expected to continue over six years camp planning was a considered operation. Various factors as topography of the site, climatic conditions and provision for increase in capacity are evaluated in drawing the plans. At the Kentucky damsite as shown in Fig. 1 the country is a gently rolling plain partly wooded but cleared in the area of the dormitories. Referring to the contours it is seen that the camp is on a ridge. Below El. 349 all the land was inundated during the heavy flood in the Ohio valley in January, 1937, and is subject to such flooding again. Also in the east all land below El. 375 is below the maximum controlled flood level of the Kentucky reservoir. In general, the location of the camp roads and some of the buildings takes advantage of the contours above the flood and reservoir levels indicated.

Rather extensive provisions for future roads and dwellings are indicated by Fig. 1. This is in accordance with the policy of the community planning division of the Tennessee Valley Authority. A plan is developed on the basis for a design of a camp rather than for the construction of the camp. In plainer terms a plan is made for the construction village that represents the maximum possible development. While it is unlikely that the maximum will ever be reached it is considered best to design so that expansion will proceed in an orderly and economical way should the need arise. For example, the construction schedule of Kentucky Dam extends over six years but in event this schedule is revised and speeded up, place is provided for the additional housing.

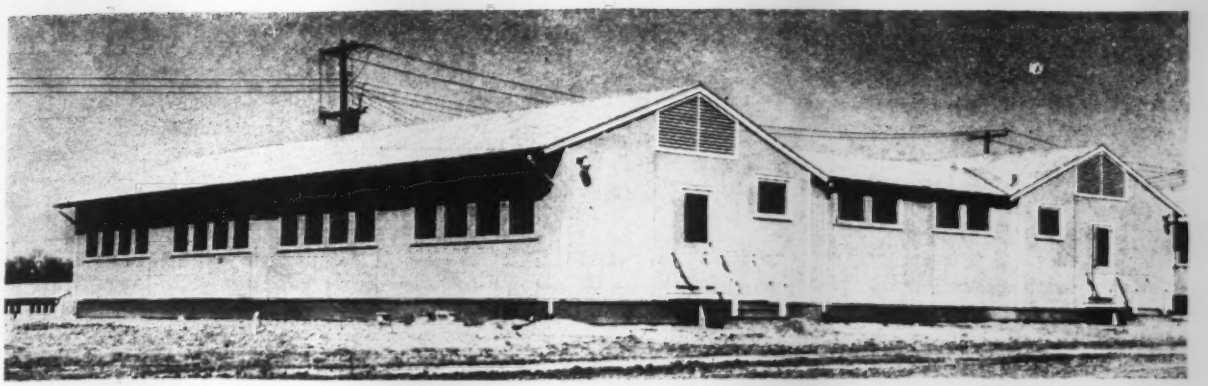


Fig. 2. Two-wing workmen's dormitory at Kentucky Dam with toilets and lavatories in closed end.

Referring to Fig. 1, as at other TVA projects, the dormitory group comprises an integral unit of the construction village. In addition to the dormitories there are a number of single-family dwellings and a group of office and service buildings, including the administration building, auditorium, cafeteria, community building, construction office, hospital and school.

Of the nine dormitories completed, under construction and projected, seven are for white persons and two are for negroes. The dormitories for white employees are arranged in the form of a horseshoe, four on one side and three on the other. The personnel office building occupies the closed end of the horseshoe. The dormitory access road follows the inner curve of the horseshoe and provides parking space as well as access. The two negro dormitories, together with a negro school, are on a separate road several hundred yards from the white dormitories.

Accommodate 60 men

The dormitories themselves are one-story, U-shaped structures, each designed to accommodate 60 men. The wings of the U contain the sleeping quarters and the closed end, or the yoke, contains service facilities—lavatories, toilets and showers. The yoke end of each building faces the access road and parking area, thus assuring occupants of minimum disturbance from street noises. The wings of the U are splayed slightly to fit the radial site plan (Fig. 3).

Various other shapes and sizes had been tried at earlier camps. Capacities ranged up to 160 men in some buildings. From the standpoint of efficient operation, however, the 60-man dormitory has proved most satisfactory. At Norris, site conditions necessitated the use of two-story buildings. As in all multiple-story structures, however, there was a degree of fire hazard not present in one-story buildings. Furthermore, second-floor noises proved considerably annoying to first-floor occupants, many of whom were often on a shift that was sleeping while second-floor occupants were returning from or leaving for work.

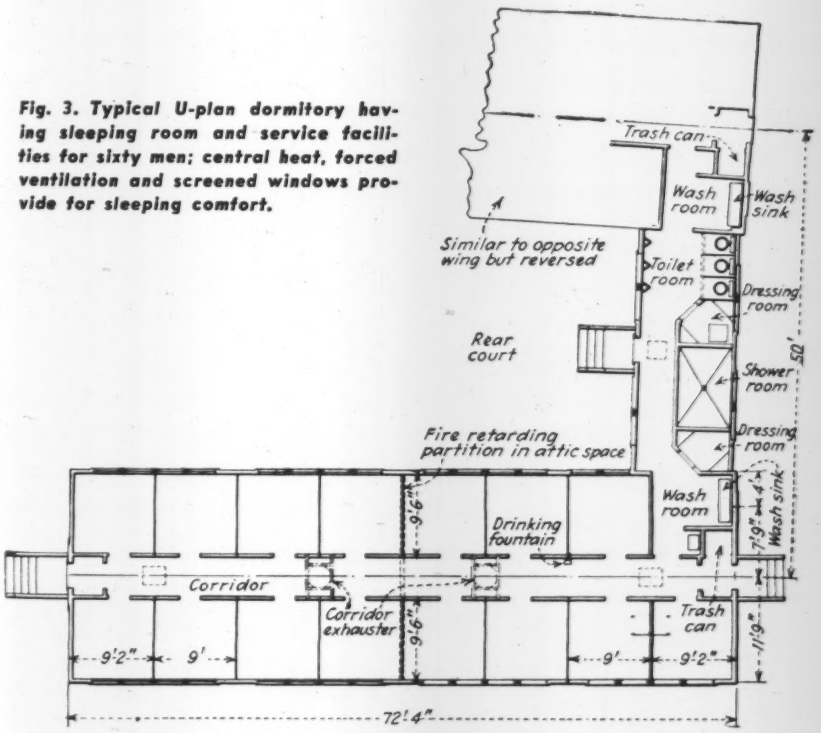


Fig. 3. Typical U-plan dormitory having sleeping room and service facilities for sixty men; central heat, forced ventilation and screened windows provide for sleeping comfort.

Bunkhouse details

The substructure of the dormitories consists of 8-in. square creosoted wood posts, spaced 8 ft. on centers and resting on 2-ft. square woodblock footings. This type of footing was substituted, for reasons of economy, for concrete pads which were used at all other camps except Norris. Termite protection is provided by 28-gage galvanized-iron shields placed on top of the foundation posts and extended between posts directly under the wood girders which support the floor joists.

Double flooring is used throughout. Finish No. 2 oak, tongue-and-groove strip floors on 15-lb. red-resin-sized building paper are laid over No. 3 oak subflooring. The entire substructure is enclosed with a flush-jointed, horizontal 1 x 8-in. shiplap curtain. The extra expense of boarding-up the substructure is justified by the reduction of heat losses. Dormitories at the first four camps were not originally

thus enclosed, although it eventually proved an economy to enclose them.

The superstructure of Kentucky bunkhouses consists of 2 x 4-in. studs, spaced 16 in. on center, which support 2 x 4-in. ceiling joists and 2 x 6-in. roof rafters. Wood strips, 1 x 3 in., spaced 15 in. on center, longitudinally support 29-gage, 5-V-crimp galvanized roofing. Galvanized iron gutters, connecting with galvanized downspouts, are attached to the overhang. Galvanized surfaces are not painted when first installed, although they may be in the 6-yr. period these structures are expected to be in use.

All exterior wall surfaces above the foundation enclosures are covered with a relatively dense and weatherproof insulating board, in 6 x 10-ft. and 4 x 14-ft. sheets laid up in plaque design with lapped joints. Hitherto all exposed walls of dormitories have been of lapped horizontal shiplap, combined in some cases with shingles, in other cases with vertical boards and battens. Insulating fiberboard for exterior use was first tried on individual family dwellings at Hiwassee where it satisfactorily stood the test of performance. As a surfacing material it has some advantages over lumber not only because of its greater insulating property but also because it is applied in large sheets, which results in a reduction of construction costs and simplifies vermin control by eliminating wall cracks.

Unpainted insulating fiberboard is also used for interior walls, providing an inner lining for the exterior walls and serving as partitions between cubicles. Exterior walls, wood trim and sash are painted.

Ceilings of the Kentucky dormitories are of insulating fiberboard, blanketed by a 2-in. thickness of mineral wool. This combination increases operating economy by reducing heat loss and increases the comfort of the occupants by providing a warmer building in winter and a cooler one in summer.

Living rooms and services

Each wing of the dormitories is ventilated by two electrical centrifugal exhausters in the ceiling of the corridor. Exhaust air is drawn through ceiling grilles into the attic and leaves the building through wood louvre gable ventilators. These vents and ceiling grilles are provided with plywood covers for use during the winter. The attic of each wing is bisected across the short axis by a solid smoke-seal, fire-retarding partition of sheetrock applied to each side of a 2 x 4-in. stud wall.

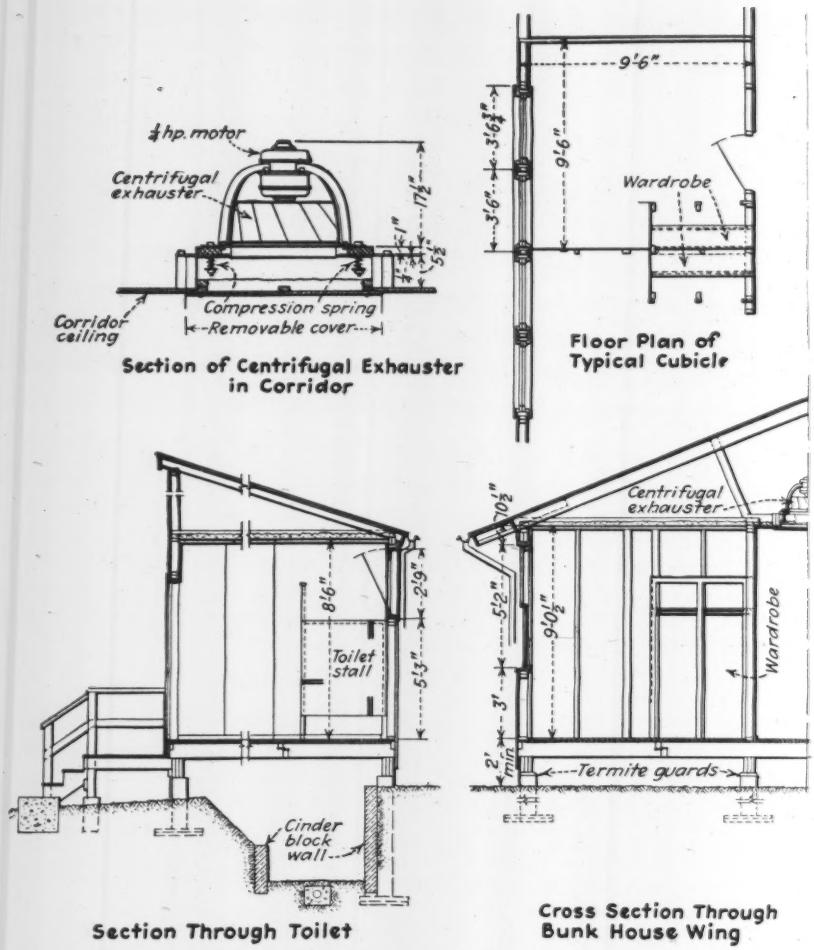


Fig. 4. Typical sections indicate main superstructure dimensions and structure of workmen's dormitories.

Cubicles in the U-type dormitories are arranged in two parallel rows in each wing. There are eight cubicles in the outer row and seven in the inner row, making 15 cubicles per wing, 30 per building. An exit is provided at each end of each corridor, and an additional exit opens onto the court from the yoke of the U, making a total of five exits per building.

Each cubicle is a 9-ft. cube and accommodates two men. A 2½ x 6½-ft. door, raised 1 in. above the floor, with a 2-ft. transom above, opens from the corridor. Twin double-hung windows, with full-length screens, are provided for each room. The windows are arranged in sets of four, permitting maximum economy of design and construction. In each cubicle there is a double, built-in, open-front wardrobe, 6 ft. 10 in. high, with hanger rod and shelf. Furniture includes a double-deck cot, a table and two chairs.

In the Wheeler dormitories, which were rectangular in shape and housed 120 men each, occupants' quarters were not entirely enclosed but were separated by 4-ft. partitions. Open stoves centrally located, rather than individual cubicle heaters on a central steam plant, provided the heat. While this arrangement resulted in the lowest cost per man of any of the TVA dormitories, it was not used again. In the first place, the heating system proved inadequate, and in the second place the open cubicles failed to provide either adequate privacy for the occupants or protection for their personal effects.

Cubicles in the Kentucky dormitories are heated by small steam radiators connected to a central heating plant. Limited power will be available at the Kentucky project during construction; consequently it

was deemed inadvisable to use electric heat, as was done satisfactorily in dormitories at several other projects. A ceiling outlet with two extension cords supplies electric current for lights.

Connecting the two wings is the yoke, in which are located lavatories, toilets and showers. Actually, the space occupied by these service facilities extends beyond the yoke into each wing as far as the corridor. In the 9x9-ft. space in each wing that would otherwise be occupied by a cubicle are a lavatory room, a trash receptacle, and a service sink or a mop closet—as well as a passage from the wing into the yoke proper. The trash receptacle faces the corridor just inside the entrance to the wing from the front of the building. Each lavatory (one in each wing) is equipped with an enameled iron 5-ft.-long wash sink with three faucets. Above the sink is a mirror.

In the yoke are the showers and toilets. The shower room has three shower heads, with mixing valves to regulate the proportion of hot and cold water. Adjoining each end of the shower room is a small dressing room with built-in benches. Entrance to the showers is through the dressing rooms. The walls of the shower room are covered with 24-gage galvanized iron, the floors are 20-gage galvanized iron. Ceilings are of insulating fiberboard painted to keep out moisture. Toilet facilities include three open-front seat water closets, separated by partitions not provided with doors, and three wall-type urinals. A door opens from the yoke, opposite the shower room, onto the court. On each side of the door is a drinking fountain.

The total cost for the first dormitory completed at the Kentucky Dam projects was $13,100 or $218 per each occupant. The average cost for each of the nine dormitories is about $10,000 or $167 per occupant. The average at Guntersville, where a similar 60-man dormitory was built, was $10,500 or $175 per occupant. It should be noted, however, that building costs rose 15 per cent, according to the *Engineering News-Record* building cost index, between the dates of construction of the Guntersville and the Kentucky dormitories.

E. S. Draper, author of this article, is now assistant to the administrator, Federal Housing Administration.

Successful Experience with Rod Sounding For Bridge Foundations

J. C. Merrell
Designing Engineer, Ohio Department of Highways, Columbus

Contents in Brief—*In ten years' use, drive-rod sounding at foundation sites for highway bridges has proved valuable in predicting pile lengths and bearing values and in proportioning spread footings where piles were found unnecessary. Sounding costs have been reduced to 78c. per foot of sounding.*

FROM 1931 TO 1935 the bureau of bridges of the Ohio department of highways in cooperation with the engineering experiment station of Ohio State University carried on extensive research to develop a field test by which the foundation requirements of a proposed highway bridge and the probable behavior of piles if driven could be predicted (Bull. 90, Ohio Eng. Exp. Sta., July 1935, "The Predetermination of Piling Requirements for Bridge Foundations"). Equipment was developed and a procedure established for making rod soundings at bridge foundation sites.

During the past five years rod sounding was continued as a regular practice for predicting pile length and bearing value, and the equipment was further improved (*ENR*, Apr. 27, 1939, p. 65). Two field parties are working continuously on sounding. Since 1931 over 51,000 lin. ft. of such soundings have been driven, half of the amount within the past 2½ yr. Experience with this work confirms the earlier conclusion that the method gives fairly precise information for predicting pile lengths.

EXPERIENCE IN PREDICTING PILE LENGTHS FROM ROD SOUNDINGS

	Summary to Oct. 1936	Summary Oct. 1936 to Dec. 1939
Number of completed jobs		
Rod soundings	76	69
Spread footings recommended	25	27
Spread footings used	27	27
Piles recommended	51	42
Piles used	49	42
Average pile length recommended	25.87 ft.	32.00 ft.
Average pile length used	25.92 ft.	32.12 ft.
Overrun or underrun of pile length, per cent of job		
Less than 10 per cent	47 per cent	57 per cent
Less than 20 per cent	72 per cent	83 per cent
Less than 33 per cent	86 per cent	93 per cent
Less than 50 per cent	96 per cent	98 per cent

The accuracy of our predictions has been increasing, as indicated by the accompanying tabular data of sounding done prior to October, 1936, and on later work for which the actual foundation construction is now completed.

Results of rod soundings enable us to predict fairly accurately when piling may be omitted, and also serve as as a guide in designing spread footings.

At the time the 1935 bulletin was printed, predictions were based on arbitrary coefficients depending on the type of soil. Since then we have accumulated a mass of data on comparison of predicted and actual pile bearing curves, and for the last several years we have obtained coefficients from the actual pile bearing curve of a preceding job in which piles were driven in similar material with similar drive-rod curve. We compile the driving logs as soon as the piles are driven and therefrom plot the actual average pile bearing curve on the same sheet as our original predicted pile bearing curve. A copy of this record is filed, with a cross-reference to the material into which the piles were driven, and the job then becomes available for reference in predicting a future job.

Sounding costs reduced

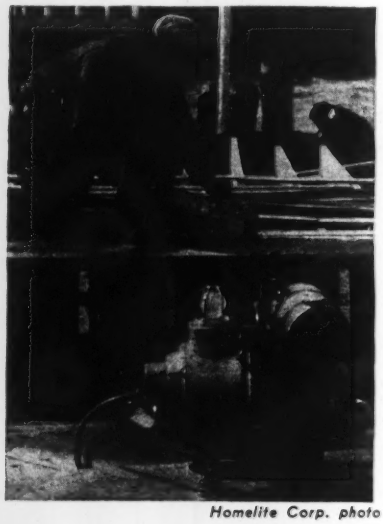
The cost of making rod soundings has decreased from year to year, as indicated by the following table, which covers all expenses including labor, equipment, depreciation, transportation and travel:

Period	Cost of Soundings
1931 to 1935	$1.89 per lin. ft.
1936	1.23
1937	1.19
1938	0.88
1939	0.78

The reduction is due to greater experience and increased proficiency of the operators, improved procedure to reduce lost time between jobs, and improvement of the equipment to speed up its operation and reduce its weight. Reduction in the weight of equipment has saved much time and expense moving into and out of difficult locations.

Versatile power saw can be used for ripping, cross-cutting, or miter, and is mounted for easy portability.

The portable electric saw may be driven from power or lighting line or, as here shown, from a portable gasoline-electric generator.



Homelite Corp. photo

Black & Decker photo

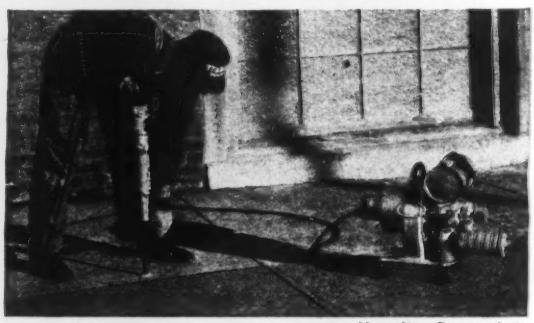
Angle drive attachment on portable electric drill permits close-quarter work.

Concrete Surfacing Machy. Co. photo

Powered by flexible shafting from electric motor strapped to worker's shoulder, this surfacer is used to remove form marks, fins, and rough spots from concrete.

Electric Tamper & Equipment Co. photo

Internal head electric vibrator operating on mass concrete. Motor is located in vibrating head.



Homelite Corp. photo

Electric hammer used to make holes in concrete, powered by 650-watt generator.

ELECTRIC DRIVE FOR ORDINARY JOBS—VIII

Small Tools

Geo. H. Hall
Mechanical Engineer, Douglaston, N. Y.

***Contents in Brief**—Small tools, their place in construction, their electric drives and connections are described in this seventh article of a series on the use of electrified construction equipment.*

CONTINUING DEVELOPMENT of small tools for use on construction provides an ever increasing number of labor-saving devices to the builder. Many of these are of the portable type which can be readily moved to the point of use and merely plugged into existing electric lines. With electric tools, sawing, drilling and countless other light operations can often be performed with a saving in both cost and time.

Vibrators

One of the newer devices using electric power is the vibrator for working and consolidating concrete in the forms. Vibration will generally produce a better and cheaper concrete than that not vibrated as the machines will "work" a lean harsh concrete where the earlier concrete placing crews would have added water and lowered the strength. Gasoline, pneumatic, and hydraulic-driven machines are on the market but for many uses the electric outfit is superior and has been proven trouble-free.

The most common forms of electric vibrators are those of the internal type in which the motor is located in the vibrating head where it gives a vibration frequency of about 3,600 impulses per minute, though some types are designed for much higher frequencies and the usual type machines may be operated faster by increasing the cycle frequency of the power. Since the motor is contained within the head, it must be of the submersible type, and the housing for it must be at least 4 or 6 in. in diameter. This is of advantage in vibrating large surfaces but, as it is frequently too large for use in limited spaces, two other types are available. A rigid type vibrator is a vibrating tube, which may be 2 in. or less in diameter, and is powered by a motor mounted above the tube thus permitting its use in restricted spaces.

Of lighter construction and available with small head diameters are vibrators driven by a flexible shaft from a motor that may be placed at any nearby point. The flexible shafts transmit power with comparatively small loss and, as the shafts may have a length of 10 to 20 ft., they afford a considerable range for the application of the vibrator without requiring movement of the motor. The introduction of gearing into the motor head also permits vibrating speeds as high as 9,500 impulses per minute.

Vibrators of the platform type, or "puddlers", have broad platforms which are vibrated by a motor built into the frame. Platform vibrators are used on extensive mass concrete projects containing large aggregate especially for smoothing of surfaces at the end of a pour. Form vibrators find frequent use on narrow, deep walls where reinforcing makes puddling and use of internal vibrators insufficient. Similar purpose vibrators are used on cement hoppers and chutes to insure steady flow and thorough cleaning. A machine with a wood spud bolted to the vibrating unit is used for vibrating precast piles and other special shapes. Relatively new are vibrating screeds on concrete road finishers usually operated by power from a gas-engine-driven generator on the machine. Electric backfill tampers find some use on trench work.

Motors used with vibrators are usually of the three-phase type although some of the smaller sizes are provided with universal motors which may be operated on either single-phase alternating or direct current.

For fabrication of concrete forms the portable electric saw is almost indispensable, a conservative estimate based on actual tests indicating that one electric saw is capable of doing the amount of cutting that can be accomplished with ten hand saws. The head of the portable saw forms the casing of the motor and is provided with suitable handles for guiding the saw during the cut. The saw blade is mounted directly on the motor shaft and guards are provided around all parts, except the actual cutting section of the blade, to render accidents unlikely. Guides are furnished to insure straight cutting. Cross-cut or rip saw blades are used interchangeably or they may be replaced by soft-metal cutting or abrasive discs for cutting slate, concrete blocks, marble or thin gage metals.

A new type of saw used on many jobs is a machine made to swing through a full arc and operate on a sliding shaft so that it can be used for cross-cutting mitre, or compound mitre, dadoing and tenoning as well as all normal rip and cut-off jobs. Some of these are trailer-mounted.

Saw motors are usually of the universal type which may be used on either alternating or direct current although some, on the larger sizes of saws, are equipped with single-phase motors which are of course usable on alternating current only.

Drills and hammers

Portable electric drills are frequently used for framing timbers and fabricating forms and, by changing to twist drills, are available for metal drilling. Motors are generally universal-wound and, while light enough to be easily handled, will drill 1 in. or larger holes through 24 in. or more of timbers. Some formwork utilizes screws in place of nails and the drills can be used for driving and removing screws and as a wrench on medium size nuts. A drill stand accessory makes a fixed shop tool of the portable drill, adding to the con-

venience and speed of use. Hole saws up to 3-in. dia. and light grinding wheels are available attachments.

Often used on building construction are portable electric hammers with star or diamond drills for making holes in concrete, stone or brick. Cold chisels may also be used in these hammers for channeling, chipping and smoothing concrete and for other applications where a sharp cutting blade is required. The motor is mounted in the head which, like the wood drill, is provided with a convenient pistol grip with a trigger for operating the motor switch. A cylindrical sleeve carries a piston and ram by which the blows are transmitted to the tool shank. The piston does not strike the shank but drives the air-cushioned ram so that the force of the blow is imparted by the compressed air rather than by direct contact, thereby keeping wear to a minimum. The universal-wound motor is geared to the piston with a reduction which cuts the speed to 2,000 to 2,500 blows per minute.

Other small tools

Electric grinders used in construction work are of two distinct types, surfacing grinders and tool grinders. Many concrete jobs call for surfacing, so it is natural that the surfacing grinder should be widely employed for finishing the surfaces of all kinds of concrete structures, as one man with an electric surface grinder will do the work of four or five men at hand surfacing. In the self-contained type of grinder, the motor is enclosed in a weatherproof and watertight casing and provided with gears driving a shaft upon the end of which is mounted a cupped surfacing wheel. Up to a certain point the weight of the motor is of advantage in adding pressure to the work and, in the small sizes, is not too heavy for convenient handling especially in the floor finisher types.

Of entirely different type of construction is the electric tool grinder which is essential to all kinds of construction work for sharpening drills, chisels and other kinds of tools. Its construction involves a fully enclosed, dust- and watertight motor with the shaft extended at both ends for carrying a pair of grinding wheels, one for coarse and one for a fine grade of finishing. On the ends of the bearing housings wheel guards and spark shields are mounted, with provision for shatterproof eye shields, the use of which is strongly recommended. Single or three-phase motors may be used which, on 60 cycles, run at a speed of 3600 rpm.

In the foregoing paragraphs have been outlined briefly the various types of electrically-operated small tools in most common use on construction projects. Other tools which find more or less occasional use are electrically equipped sump pumps, water supply pumps, tool branding devices, hoists, power units, car spotters and many others, the demand for which may arise on special construction projects. One tool often taken for granted on a job is the electric forge blower which must be dust- and weatherproof.

Motor equipment and wiring

Many of the small tools here enumerated are obtainable with single-phase motors though some of the larger motors are more economical with the complicated construction and wiring of three-phase equipment. Many of the smaller machines have universal motors which permit their use on direct as well as alternating current. Practically all of the small tool motors are of a capacity which may be started by throwing directly on the line so that a simple starting switch, with proper overload protection, is all that is required for their control.

The operating voltage of most of the small tools is either 110 or 220, that generally available on lighting and small power circuits. For 110-volt connection, the flexible leads from the tools are plugged directly into a lighting socket, while for 220 volts they are connected to the outside wires of the system through power outlets.

Three-phase motors are of course connected to the three power lines as are higher voltage motors of this type although, since the power distribution is usually at 440 v. or higher, a small three-phase transformer for reduction to 110 or 220 v. may be needed. Such a transformer should be located as close as possible to the tools for which it is to supply the power so that the line loss incidental to the lower voltages may be avoided. Care should also be taken, in providing the flexible leads, to select only those of sufficient size to transmit the power without undue loss, since the use of undersized wire will decrease the power actually delivered to the tool with a corresponding reduction in its working capacity.

Generating sets and cable

On non-electrified jobs and at isolated points even where electricity is generally available, demands occur for the use of portable tools. The use of a gasoline-driven generating set mounted on a common frame, which can be located near the work, may eliminate construction of long lines and resultant power losses. Such generating sets are used to a large extent where only a small amount of power is needed for driving small tools or for temporary lighting. Large portable units, some diesel-driven and equipped with elaborate switchboards, are also available. The smaller sizes are generally designed for single-phase and those of larger capacities made for three-phase output. As many of the portable tools have three-phase motors, three-phase generators are needed for their operation while single-phase motors may be operated from the three-phase generators by connection to but one of the phases.

The three-phase generators are provided with three-wire outlet plugs from which the portable cables are run directly to the tools while, if single-phase tools are used, connection is readily made to any one phase by use of an adapter which is plugged into the three-phase outlet at the generator and is provided with three single-phase sockets into which may be plugged an equal number of single-phase lines. Y-connectors are also available, so constructed that two portable machines may be connected to a single outlet.

Cable manufacturers have produced cables protected with a heavy coating of rubber and cord, more flexible than the ordinary power cables, for the unusually severe handling this equipment gets around a construction job. The makers of the portable tools can usually be depended upon to provide suitable cables of the proper carrying capacity of either two or three-wire construction and, when required, to incorporate a grounding wire which is always green-covered for identification. If cable is to be purchased from the regular cable makers, full information should be given as to the specific purpose for which the cable is to be used.

Meter Practice at Grand Rapids

***Contents in Brief**—In Grand Rapids batteries of small meters are found more efficient and less expensive than single large ones. A regular time schedule of meter removal for testing has been established and with this has come the establishment of a new meter history system.*

In the Interest of Economy and better service several improvements have been made within the last few years in operating the Grand Rapids (Mich.) water department. Among points noted in a recent visit of a representative of *Engineering News-Record* are the following: Batteries of small meters have largely replaced single large meters on services of high-consumption users; a schedule of removing all meters every five years has been initiated; a modern loose-leaf and card meter record and reading system is maintained; high unaccounted-for water is being cut by a leak detector; and to avoid electric shock to meter crews meters are bypassed by wire loops.

Since the readiness-to-serve charge on a 6-in. meter is $312 annually, and only $22.40 on each of nine 2-in. meters which will pass an equivalent amount of water, large users save money by installing batteries of the smaller sizes despite the fact that the smaller meters catch the low flows. A 6-in. meter used under Grand Rapids conditions where lime incrustation is severe often will not record a ¾-in. stream, thus representing a tidy sum lost to the water department. While the gain with the 2-in. meters is more than the difference in service charges the consumer is paying for water used and everybody is better satisfied.

All services metered

Grand Rapids has meters on practically all of its 40,000 services. Only on such services as fire sprinklers and street and sewer flushing are meters not installed. Public buildings, churches and institutions all have meters. The sprinkler service is paid for on a readiness-to-serve basis. In consequence the Water Department has a 95 percent metered system but until three years ago removal was not made so long as a meter apparently was registering correctly. Some meters had been in service 40 to 50 years.

Tests disclosed that many meters were greatly under-registering. With the advent of the new record system which is not yet entirely complete the oldest meters in use are being brought in for testing, cleaning, repairing, condemnation or return. A small percentage of the 40,000 meters in service longer than five years are still to be brought in. A colored clip on the history card system which is essentially that furnished by the Remington-Rand Co. indicates the year in which the meters have been set recently with a single green color for all back of 1936. The history cards are arranged by streets and the old meters are brought in one after the other down the street to save the time of the meter crews.

As noted the system is essentially the commercial card system that is in use in other cities with special adaptation to the local conditions and requirements. To avoid fire hazard two sets of records are maintained. To expedite and correlate the work of handling meters the reading, installation, testing and repair department is located at the main pumping station and the administrative, financing, billing and collection department is at the city hall. Each department has a card file. That at city hall is segregated by name of consumer and that at the station by streets and numbers on the street.

Meter readings are taken every three months on 4x8-in. sheets in loose-leaf books with spaces (including both sides of the sheet) for 28 readings covering seven years. As is now general, readings start at the bottom of the sheet for ease in subtracting to get consumption data. Route books have from 150 to 200 accounts each. For or six of these

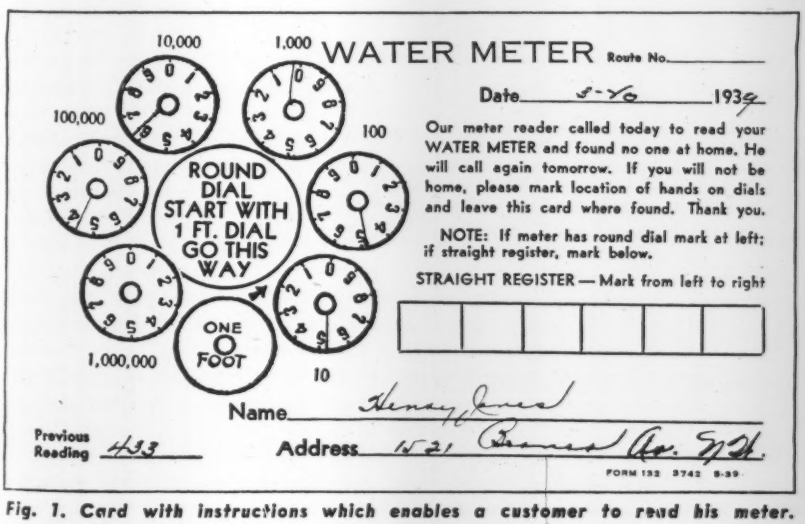

10,000
1,000
WATER METER
Route No.
Date 8-Y6 1939
100,000
100
ROUND DIAL START WITH 1 FT. DIAL GO THIS WAY
Our meter reader called today to read your WATER METER and found no one at home. He will call again tomorrow. If you will not be home, please mark location of hands on dials and leave this card where found. Thank you.
NOTE: If meter has round dial mark at left; if straight register, mark below.
STRAIGHT REGISTER — Mark from left to right
ONE FOOT
1,000,000
10
Name Henry Jones
Previous Reading 433
Address 1521 Bonner Ave. NW
FORM 132 3742 8-39

Fig. 1. Card with instructions which enables a customer to read his meter.

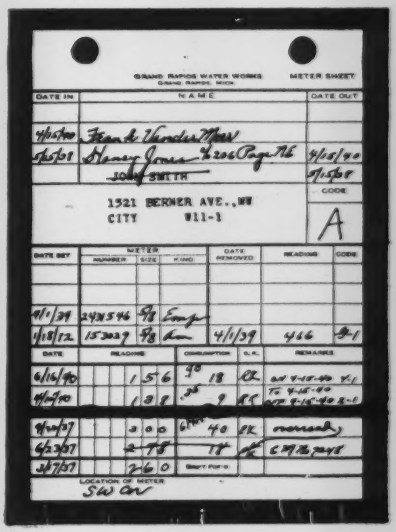


Fig. 2. Meter sheet which has space to record a reading every 3 months for seven years.

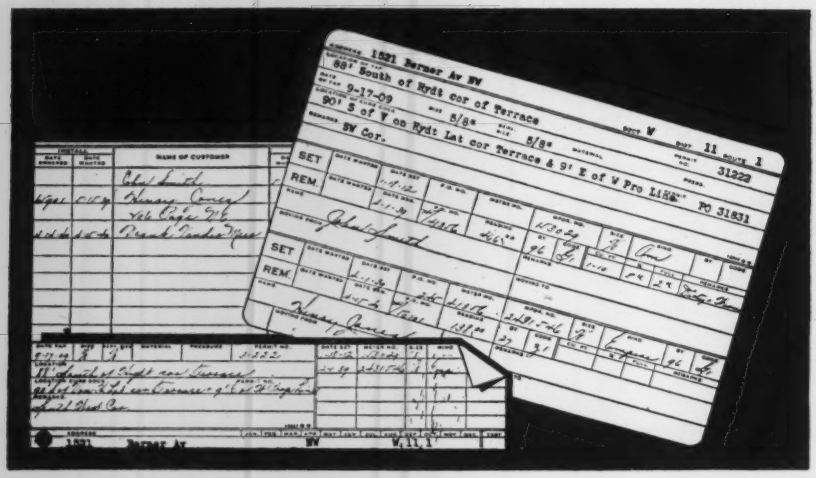


Fig. 3. Meter history cards filed by street addresses. This is a buff colored "field card" in and out and is filed on top of a white thin-paper history card with black spot at lower left uncovered when field card is out.

GRAND RAPIDS SERVICE AND METER CODE

A .....Change meter—stuck
B .....Change meter—leaking
C .....Change meter—test
D .....Change meter—noisy
E .....Change meter—cannot be read
F .....Increase meter from—— to ——
G .....Decrease meter from —— to ——
H .....Cut off—rates
I .....Cut off—vacant, remove meter
J .....Cut off for winter
K.....Cut off for repairs
L .....Turn on—rates
M.....Turn on—reset meter
N .....Move meter
O .....Raise meter
P .....Change meter—discontinued
Q .....Get house number
R .....Inspect for pressure
S .....Inspect taste in water—get sample
T .....Inspect discolored water—get sample
U .....Inspect source of water
V .....Inspect high bill
W.....Inspect service leak between meter and main
X .....Inspect size, number and kind
Y .....Check reading
Z .....Cut off at curb—no more use

A-1 .....Install shut off—broken
B-1 .....Repair shut off—leaking
C-1 .....Meter couplings leaking
D-1 .....Get curb box location
E-1 .....Repair curb box
F-1 .....Move meter inside from outside fill in meter box, install curb box
G-1 .....Change meter cycle
H-1 .....Change meter—slow
I-1 .....Make special meter reading
J-1 .....Inspect, see if water is on
K-1 .....Remove meter
L-1 .....Remove meter—no more use
M-1.....Get reading—not read
N-1 .....Cut off—no meter
O-1 .....Cut off at main—no more use
P-1 .....Inspect—frozen
Q-1 .....Raise curb box
R-1 .....Lower curb box
S-1 .....Dig and repair curb box
T-1 .....Set new meter
U-1 .....Turn on after repairs
V-1 .....Cut off—no application
W-1.....Cut off—not read
X-1 .....Something leaking
Y-1 .....Turn on and read
Z-1 .....Cut off, vacant, read.

3—Bankruptcy 4—Receivership 5—Probate

books make up a district and are sent to the meter readers each day and returned within three days with a yellow sheet of missed readings added.

Two attempts are made to get the readings missed. A card (Fig. 1) showing a meter dial face on which to note the position of the hands and also space for straight registration is left on first call so that the reading can be made by the customer, who is instructed to replace the card where the meter reader left it. If this card is not filled in a minimum bill is rendered and the case dropped until the next half-yearly reading time arrives. Drastic action is then taken. If the meterman cannot get into the house a card is left indicating that a shut-off order will be carried out if the meter is not read in five days.

In all the above recordings much time is saved by the use of the accompanying code table on the various cards, work orders and notices. The meter service men are not acquainted with the last three code items to avoid embarrassment in conversation with the occupant.

Leak prevention

When unaccounted-for water a few years ago reached 34 percent, J. J. Wernette, superintendent, started a leak prevention program and employed a concern utilizing a vibration type of detector. Some 350,000 gpd. leakage was discovered at a cost of $2,500. The department then purchased the detector and within the last two years 600,000 gal. of leakage has been discovered. One of the first leaks found was in a downtown street where a heavy flow into a sewer indicated a large leak. Three 3x6-ft. holes costing $45 each were cut in the street but failed to locate the leak. In the middle of the night the detector was set on the pavement and located the leaks despite the fact that the soil directly over the leak and under the pavement had sunk and left a cavity.

It is the practice in Grand Rapids to ground electric house wiring to water pipes. In consequence if much current is being carried removal of the meter may give the workman a severe shock when the meter couplings are disconnected. As a protection measure the department has ordered the local electric company to install a wire bypass around each meter. Much less electrolysis has occurred in the city since buses have replaced trolley cars. A few users of direct current for elevators in the business district still produce return current difficulties, however.

Many concerns in Grand Rapids have air conditioning equipment, some 35 to 40 utilizing water from private wells 300 ft. deep since the temperature of this water runs about 60 deg. Two difficulties have arisen. The groundwater level has been reduced 17 ft. and shade trees have begun to die in certain areas. Salt water is encountered and has a serious corrosive effect on pipes not only in the air conditioning system but in the sewers. Unfortunately the season for air conditioning comes with low water in the river so that the additional salt content causes downstream complaints from cattle owners.

In view of these difficulties the City Commission recently has ruled that well water from air conditioning systems must be returned to the ground. The return is usually done through a new well at least 20 ft. away from the original well. With the advent of Lake Michigan water which will be uniformly at 53 deg., it is expected that many of these air conditioning plants will switch over to the use of city water. Since the quantity will be large the charge will fall in the lowest step of the rate schedule (6½c. per 100 cu. ft.).

The Grand Rapids Water Department is operated under the city manager, C. Sophus Johnson, directly under Peter A. Kammerad, service director. J. J. Wernette is the superintendent.

Stabilized Mud for Building

E. L. Hansen
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***Contents in Brief**—Illinois tests indicate that a useful building material can be made on the site from stabilized mud, by mixing the soil with emulsified asphalt and water and drying it in the air. Nearly all Illinois subsoils were found suitable. The 200-mesh material should be held to 20-30 percent, emulsion to about 5 percent of the total mix. Different emulsions differ greatly in efficiency.*

MATERIAL for building walls can be found on nearly every building site, according to recent investigations with Illinois soils. Subsoil such as is found almost anywhere, emulsified asphalt and water are required. Specimens of brick molded of such material stood ten months of weathering excellently, as may be seen from Fig. 1. Such bricks are very resistant to abrasion, moreover; 100 strokes of a steel wire brush removed no material, while a similar brick mixed without the asphalt stabilizer lost as much as $\frac{1}{2}$ in. under the same treatment.

How to use stabilized soil

Mixing, molding and curing these stabilized soil blocks is simple. First the soil is analyzed to determine the content of 200-mesh material, and enough sand or gravel is added to reduce this content to about 25 percent. Adding the right kind of asphalt emulsion in an amount equal to 20 percent of the 200-mesh material, or about 5 percent of the total mix, provides all the necessary elements. Mixing may be done in a concrete mixer, or, better still, in a mixer that requires less water, such as a paddle mixer or pug mill; if a concrete mixer is used, it is best to put the water and clay in first and thoroughly mix, then add the stabilizer and again mix thoroughly, and finally add and mix the sand or gravel. If the material is too wet to mold after mixing, it may be spread out to allow some of the water to evaporate.

For ready molding the mix should be quite stiff. Thorough packing is essential to produce strong, solid blocks. Casting should be done on an absorbent surface, if possible. The mold is immediately removed, cleaned, wetted and used again.

A suggested size of block for constructing small one-story buildings is $4\frac{3}{8}$ x $12\frac{3}{4}$ x $16\frac{3}{8}$ in., or other multiple of common-brick size. The blocks are cured by air drying, much the same as adobe blocks. Too rapid drying during the initial stage is not advisable. In tests, temperatures from 70 to 175 deg. F. had no effect on stability, but less absorption occurred in specimens cured at 140 deg. F.

To build with such blocks it is best to use a footing of concrete and start the block wall above grade, and to waterproof the top of the footing so that capillary water will not reach the blocks. Probably stabilized soil can also be rammed into walls, as in ancient rammed-earth wall construction, but blocks have the advantage of convenience. They can be laid up with a mortar of the same material as that used in forming the blocks.

A 12-in. wall built of stabilized soil affords good protection from the elements. The thermal conductivity of the material is 3.5 B.t.u. per sq.ft. per hr., per inch of thickness and degree Fahrenheit. This compares with the conductivity of lightweight concretes, such as those made with haydite or cinders. A 12-in. soil wall has the same resistance to heat transmission as the stud wall of a frame house built with tight sheathing of 25/32-in. wood siding on the outside and $\frac{3}{4}$-in. plaster on metal lath on the inside. The permeability of soil walls to water vapor is small, tests showing a value of 8.49 g. per sq.ft. per day for each pound per square inch vapor-pressure difference, per inch thickness.

Soil walls can be painted, or the material may be colored in the mixture, or it may be left in natural color—a chocolate brown. Light tints are not successfully applied because of the asphalt, but shades of

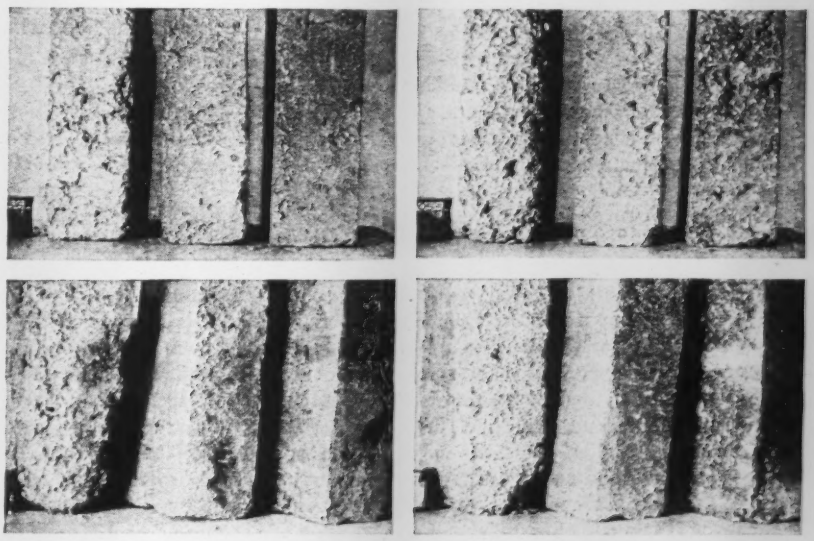

Fig. 1. Bricks of stabilized soil after ten months' weathering. Left-hand group, 30 percent fines; right-hand group, 20 percent fines. Upper group, not in contact with ground; lower group, nearly buried. Each set of three represents three different amounts of stabilizer, 15, 20 and 30 percent of the fines.

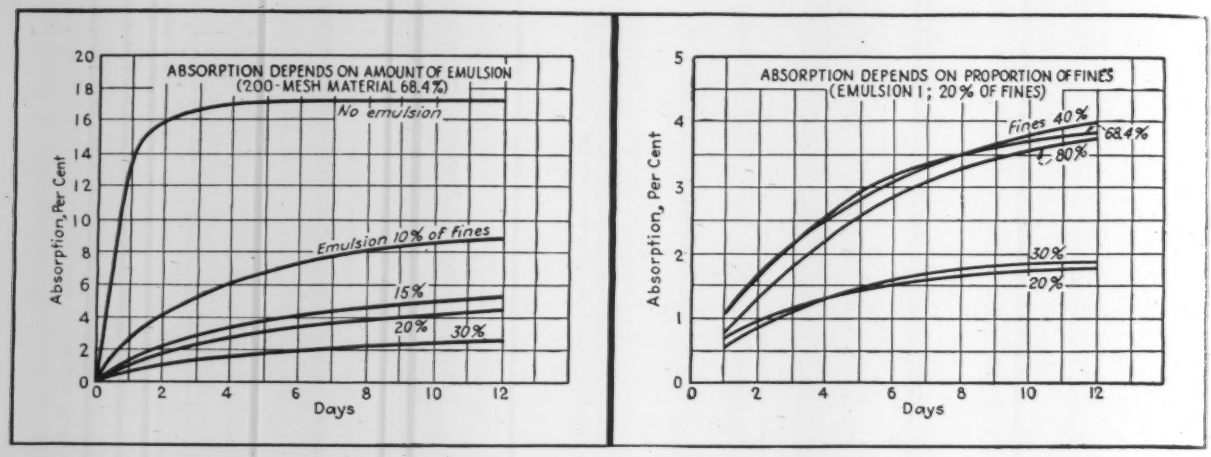

Fig. 2. Absorption depends both on amount of stabilizer and fines, the latter being about 25 percent of the mix.

red, black and brown are readily obtained. If only the outside of the block is to be colored in the mix, a thin layer of the colored mix can be placed on the top or bottom of the mold. The same material can be used as a plaster, if the coarser material is removed; such plastering may be done directly on the block.

A satisfactory coating can also be obtained by painting the wall with aluminum bronze paint, made by mixing aluminum bronze powder with asphalt emulsion. This produces a satisfactory surface especially for farm buildings, and effectively waterproofs the walls.

The Illinois investigation has proved so successful that stabilized soil will probably be tried out in chicken houses, hog houses and other small farm buildings. Further, several home builders in Illinois are interested in trying it out for low-cost dwelling houses. Full construction details have not been worked out, but those used in adobe and rammed earth construction elsewhere are readily adaptable.

Some of the test results

Among the qualities of stabilized soil that were studied are strength, durability, heat permeability, insulating value and color possibilities. Complete tests were made with a single subgrade soil which contains 64.8 percent of 200-mesh material. With this basic soil, all of the many variables were investigated, including percent of fines, proportion of asphalt, effect of various commercial emulsions, stability of the mixed soil, effect of packing, effect of curing temperature. Durability was studied by measuring absorption, determining resist-

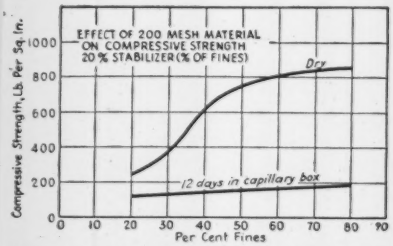
EFFECT OF 200 MESH MATERIAL
ON COMPRESSIVE STRENGTH
20% STABILIZER (% OF FINES)
Dry
12 days in capillary box
Compressive Strength, Lb. Per Sq. In.
Per Cent Fines

Fig. 3. Compressive strength is reduced by absorption of moisture.

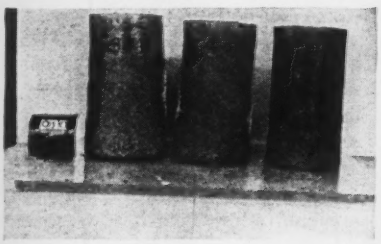

Fig. 4. Good resistance to freezing and thawing was obtained with 15 to 30 percent of stabilizer, rated on amount of fines.

ance to freezing and thawing, and observing shrinkage and swelling effects. The amount of fines was varied by adding sand in different amounts.

Fines Must Be Limited—The properties of the stabilized soil depend not only on the stabilizer but also on the amount of fines in the soil. Both influences are represented in the absorption curves Fig. 2; the left-hand curve shows the effect of amount of stabilizer on a soil with 68.4 percent of fines (200 mesh and under), while the right-hand curve shows the influence of varying percentage of fines. The latter curve suggests that 30 percent of fines is the maximum that should ordinarily be used. Tests with other soils showed similar results. Limitation of fines is desirable also to reduce shrinkage and swelling, minimize cracking during curing, economize in amount of stabilizer, and make working easier. Shrinkage and swelling approach zero at 20 per cent of fines.

Strength and Stability—Compressive strength also is influenced by the proportion of fines (Fig. 3). When the content of fines is between 20 and 30 percent, the cured blocks have a strength of 250 to 350 lb. per sq.in. in dry condition. Strengths over 400 lb. were obtained with some soils. These strength tests were made on 2-in. cylinders 4 in. high.

Great differences were found in the effect of different emulsions. Seven emulsions gave widely varying results, and after the preliminary tests the emulsion that was best in absorption and stability was used in all the further tests.

Stability was measured by the resistance to plastic flow of the stabilized soil after seven days' absorption, the soil being extruded through an orifice of 1-sq.in. area in the bottom of a 2-in. cylinder, and the load required to move the plunger ½ in. being taken as measure of the stability of the material. Different emulsions showed stability values ranging from very low figures to more than 10,000 lb. per sq.in., and in general those which produced the highest stability also showed lowest absorption.

Resistance to freezing and thawing varied with resistance to absorption, as might be expected. The specimens shown in Fig. 4 had been subjected to eleven cycles of freezing and thawing; the three specimens contained 15, 20, and 30 percent of stabilizer.

rated in relation to the amount of fines. The left-hand specimens showed some bulging, while the one at the right remained unaffected. These results were obtained with the emulsion selected from comparative tests. Specimens made with other emulsions failed after 2 to 9 cycles, while those pictured would probably have gone through 15 to 18 cycles.

Conclusions—Nearly all Illinois subsoils are suitable for stabilizing. The amount of fines should be reduced to between 20 and 30 percent, and the proportion of stabilizer should be about 20 percent of the fines, which with 25 percent of fines means 5 percent of the total mix. Emulsions differ greatly, and all emulsions are not satisfactory. Compressive strengths of 250 to 400 lb. per sq.in. are commonly obtainable. The weight of stabilized soil is about 100 lb. per cu.ft.

The size of coarse material added is not critical except to ease of molding; sizes up to ½ in. seem satisfactory for small blocks. The mix should be molded near optimum moisture and should be well packed into the mold by ramming or otherwise. The blocks must be thoroughly cured by air drying before using.

The investigation was made under the direction of Prof. John S. Crandell and the writer.

How to Use Limit Design

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Indeterminate structures exert their principal advantage over simple frameworks through the continuity of their members, which permits overloaded parts to be aided by the carrying capacity of other parts. Because of this fact, the design philosophy (conventional for simple structures) that would permit no member to be stressed beyond its yield point is held by some engineers to be uneconomic for continuous frames. They have proposed a design theory that would determine the point of ultimate failure of the structure, regardless of how many members or joints had previously had their carrying capacity impaired because of excess deformation or stress, and then apply to this ultimate load a suitable factor of safety. Such a theory is not new but until Prof. J. A. Van der Broek of the University of Michigan published a paper on it in the February, 1939, Proceedings of the Am. Soc. C.E., wherein it was named the theory of limit design, it had not been given formal notice in this country. As a result of that paper and of successful full-scale tests of steel transmission towers redesigned by the method by C. M. Goodrich, chief engineer of the Canadian Bridge Co., much discussion has ensued. The following article, which applies the theory of limit design to a simple, indeterminate structure, should aid in an understanding of this discussion. The author has just completed testing a two-span welded I-beam rigid frame at the University of Minnesota to provide an additional check on the assumed theory.

In Statically Indeterminate structures, if stresses at some isolated point reach a certain critical value, failure is usually prevented by a shift of the carrying capacity to one or more other critical points in the structure. This fact may be turned to advantage by utilizing the theory of limit design wherein the factor of safety is based upon the structure as a whole rather than on individual members. To demonstrate the problems encountered in such a design procedure a rigid frame bent, as illustrated in the accompanying sketches, is an ideal example.

A certain dead load, w_1 over the entire length is assumed. This value is doubled and in the final design load is returned to its original value. The positive bending moment in the continuous horizontal member is most critical when only the middle span l_2 is subjected to live load w_2. The bending at B in the center span will be greater if all three spans are fully loaded, but the bending at G would be decreased. For failure of the structure, points B, C and G must reach hinge action, i.e., these sections must have reached their maximum resisting moment as shown by the rectangular stress distribution in Fig.

While this state is theoretically impossible of full realization, actually there is a maximum moment at which a given simple beam will continue to yield without increase in load. The total load at which sections B, C and G will reach hinge action is the failure load for the structure.

A typical problem

Fig. 3 gives the dimensions and physical characteristics of the structure used in this analysis. The I/l or K values are relative. A uniform dead load of 400 lb. per ft. is assumed. Fig. 4 gives the moments developed with an 800 lb. per ft. dead load. Fig. 5 gives the moments and reactions of the structure with a live load of 100K lb. per ft. on the center span. The next step is to take the values of Fig. 5 for live load and superimpose them on the values of Fig. 4 for dead load, then determine the magnitude of K which will cause the moment at B in member BC to reach the critical value or hinge action.

A 4-in. 9.5-lb. standard I-beam will resist a moment M of 120,500 in. lb. when the extreme fiber reaches a yield point stress of 36,000 lb. per sq.in. but will resist a maximum moment of 146,500 in. lb. at hinge action based on the stress distribution shown in Fig. 2.

With live and dead load combined

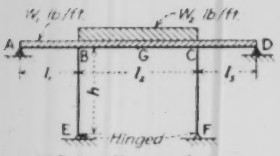


FIG. 1 — Nomenclature

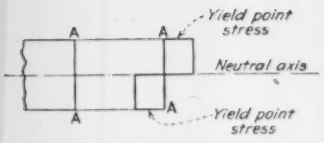


FIG. 2 — Stress Distribution at Failure

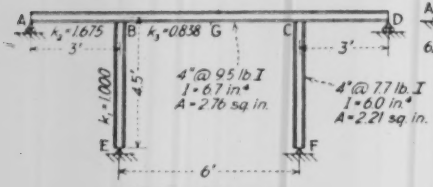


FIG. 3 — Dimensions

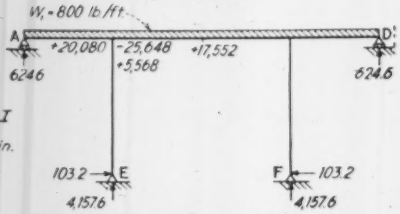


FIG. 4 — Design D.L. and Moments

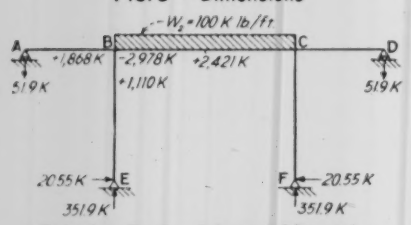


FIG. 5 — Design L.L. and Moments

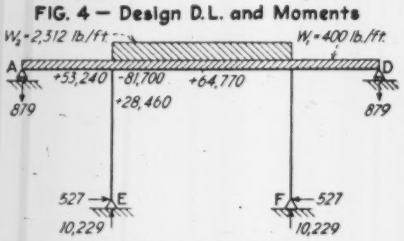


FIG. 6 — Final Design

Figs. 1 to 6 — Steps involved in applying limit design to a simple rigid frame.

the critical moment at B in member BC will be

$$+ 25{,}650 + 2{,}978K = 146{,}500$$

$$\therefore \quad K = \frac{146{,}000 - 25{,}648}{2{,}978} = 40.5$$

The live load necessary to cause hinge action at B is then 40.5 x 100 or 4,050 lb. per ft.

This load will cause a moment at G in member BC of

$M_G = 17{,}550 + 2{,}421K = 115{,}550$ in. lb.

This section will resist 30,950 in. lb. more before the critical moment of 146,500 in. lb. (or hinge action) will be reached. Sections at B and C in member BC continue to rotate without increase in resistance. This is because the sections have reached maximum resisting moment. Since the ends of BC act as hinges the member acts as a simple beam for additional load. The additional load necessary to cause hinge action at G is then obtained.

$$M = 30{,}950 = \tfrac{1}{8}\, wl^2$$

$$W = \frac{8 \times 30{,}950}{6^2 \times 12} = 573 \text{ lb. per ft.}$$

The total live load on the center span is then 4,050 + 573 = 4,623 lb. per ft.; and there is 800 lb. per ft. dead load on all spans. At this load the structure becomes unstable because points B, C and G in member BC act as hinges. With a factor of safety of two for the structure as a whole, the live load will be 2,312 lb. per ft. The dead load will be 400 lb. per ft. as originally assumed. The factor of safety based on live load alone will be greater than 2. Fig. 6 shows the final design loads, moments and reactions.

The load on the vertical columns BE and CF is 10,220 lb., with moments at the top of 28,434 in lb. The area required for this loading according to the formula of the American Institute of Steel Construction is

$$A = \frac{P_1}{f_c} + \frac{P_1 yn}{f_1 r^2} = \frac{10{,}220}{15{,}000} + \frac{28{,}434 \times 2}{18{,}000 \times (1.64)^2}$$

$$= 0.682 + 1{,}175 = 1.857 \text{ sq.in.}$$

The area provided is 2.21 sq.in. and therefore for column action it is well within the assumed factor of safety.

Safe load with ordinary design

With a given maximum allowable stress of 18,000 lb. per sq.in. the maximum resisting moment under ordinary design procedure would be

$$M = \frac{sI}{c} \quad \frac{18{,}000 \times 6.0}{2} = 54{,}000 \text{ in.lb.}$$

This would first be reached at section B in member BC, therefore

$$54{,}000 = 12{,}824 + 2{,}978\ K$$

$$\text{or } K = \frac{41{,}176}{2{,}978} = 13.84$$

With a 400 lb. per ft. dead load the live load in the middle span can only be 1,384 lb. per ft. as compared with 2,312 lb. per ft. by the limit design method.

It should be noticed that the final design load of 400 lb. dead load and 2,312-lb. live load gives a maximum moment at B in member BC of $12{,}813 + 2{,}978 \times 23.12 = 81{,}720$ in. lb. giving a maximum stress of

$$s = \frac{81{,}720 \times 2}{6} = 27{,}250 \text{ lb. per sq.in.}$$

Therefore the stress is well within the yield point in all of the structure. The maximum deflection under this design load is 0.183 in., or about 1/400 of the span.

Conclusions

1. The theory of limit design results in more economic use of material without loss of safety.
2. The theory should be applied in steps from one critical section to another as they progressively reach the critical stage.
3. A table of maximum resisting moments (hinge action) of various structural shapes is needed.
4. No general order of procedure can be stated to apply to different types of structures.
5. Considerably more study and testing should be made of various types of structures.

The writer was aided by Jean Dixon, senior student in civil engineering, in making calculations and drawings for this article.

It may be mentioned that shearing stresses were found to be quite low, but further studies are being made of the effect of shear on the theory of limit design.

New Indiana SewagePlants Reduce Lake Pollution

The $5,000,000 sewage disposal plant at Gary, Ind., now is reported in full operation, with utilization of sludge gas for fuel purposes. The activated sludge units of the plant were placed in operation last fall. At Hammond, the new works, costing $3,500,000, are nearly completed. Work is expected to begin next spring on the East Chicago plant, estimated to cost $2,500,000, and already approved by the WPA. Whiting has applied to the WPA for approval of its plans for a $1,250,000 plant. All these plants are intended to reduce the sewage pollution of the south end of Lake Michigan.

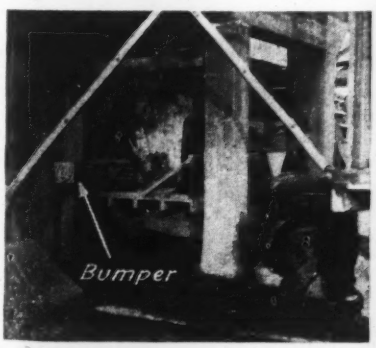
From Field and Office

Working problems and time-saving methods for engineers and contractors

Bumper Shifts Buckets

Concrete for the powerhouse and lock at Pinopolis Dam on the Santee-Cooper project in South Carolina is hauled from the mixer to the job in 2-yd. buckets set on trucks with bodies long enough to carry one full and one empty bucket. The full bucket is carried in the forward position to the job where the crane swings an empty over the truck, sets it on the back of the truck and in the return swing picks up the full bucket. The truck with the empty bucket on the rear runs to the mixer and backs in under the concrete chute. In backing into the opening under the mixer hopper a cross bumper under which the truck body slides pushes the bucket forward to loading position. This arrangement eliminates all lost motion in handling the buckets and makes it unnecessary to build a special truck body such as would be needed to carry a loaded bucket in the rear position. The Central Engineering Co., Davenport, Iowa, is the contractor on Pinopolis Dam.

A similar method was employed by Cleary Bros. Construction Co. on the St. Lucie Canal lock at Stuart, Fla., but with smaller buckets and trucks and a thorough movement under the mixer. There a chain was stretched across behind the bucket after it had been spotted and then the truck was backed until the chain had pushed the bucket to the front end of the truck. Greased steel strips were put on the truck floor to facilitate this.

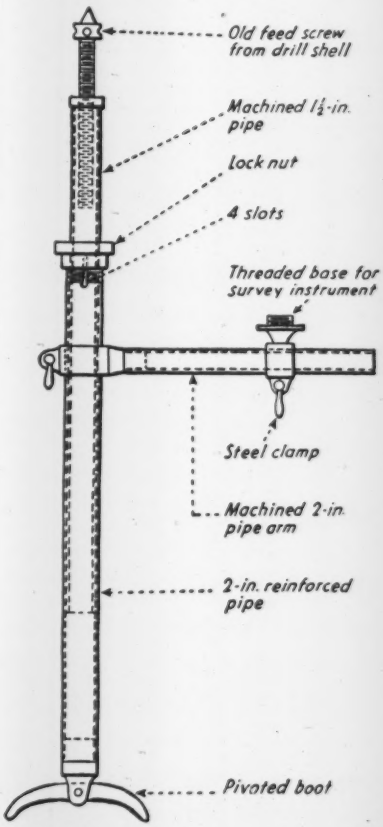


A bumper block under the concrete mixer pushes the concrete buckets to forward position

One day as a driver was bringing his truck in under the mixer a man stepped into his line of travel and he jammed on his brake. As he did so, the bucket skidded forward into position. Now the drivers run under the hopper and put on the brake quickly, skidding the bucket to position without use of the chain.

Instrument Support for Tunnel Surveys

A device that is a great convenience to underground surveyors, particularly in tunnels where frequent passage of muck trains or other activities



would interfere with setting up the instrument on the ordinary tripod, is shown in the accompanying sketch. The device consists principally of short lengths of 1½ and 2-in. pipe which telescope conveniently. On the upper end of the smaller pipe an old feed screw from a rock drill shell is threaded through a nut welded to the pipe. A lock nut that forces inward the four sections of the slotted end of the 2-in. pipe serves to hold the two sections together at any stage of extension.

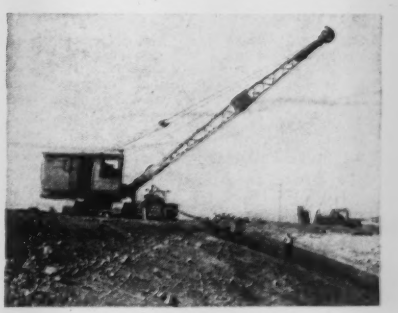
At a point where instrumental observation is to be made, the pipe is adjusted and the screw jack wedges the upright bar firmly between roof and floor. Then the instrument, either transit or level, is threaded to a base made from an ordinary tripod head fastened by a steel clamp to a horizontal pipe arm that can be locked in any desired position on the column.

With this arrangement, the surveying instrument has a considerably wider range, both horizontally and vertically, than on the ordinary tripod, and it cannot be knocked down. If desired, the horizontal arm and the instrument upon it can be swung out of the way while a muck train passes and then can be returned, with the aid of the plumb-bob and a marker on the vertical column to the exact position previously occupied.

Dragline Rolls Dam Slopes

Effective compaction of the sloping face of Hansen Dam, an earthfill structure in southern California, was obtained by using a dragline mounted on crawlers to operate a pair of sheepsfoot rollers up and down the slope. The usual tamping methods on the surface of the fill are least effective at the edge of the slope, where a small portion of each layer cannot be reached at all. Lacking in compaction, this loose material is quick to erode from the sloping surface when rainfall occurs during construction.

Erosion of this sort on Hansen Dam was replaced by bulldozing additional material down from the crest. Hand tampers were used to



Double-drum sheepsfoot roller replaces dragline bucket for compacting Hansen Dam slopes.

pack it into place where narrow gullies had been formed and then the surface was thoroughly rolled as shown in the accompanying view. With this rig 14 to 18 passes were the equivalent of the tamping on the top surface given by full size sheepsfoot rollers.

Maximum Moment Curve

Various methods have been published for sketching an approximate simple-span bending-moment curve for a series of concentrated loads, such as the wheels of a locomotive; a favorite method being to plot two halves of a second-degree parabola separated by one-tenth of the span.

Twelve years ago the writer devised an accurate, convenient and logical approximation that he has not seen proposed elsewhere; namely, a fourth-degree parabola that passes through the maximum moments at the center and quarter points of the span. This curve may be plotted quickly by use of the coefficients in the Table I, which gives the values of C in the equation: $m = CM$ where

M = the bending moment at the center of the span;

m = the bending moment at a distance kL from the center of the span L;

C = a coefficient that is a function of the ratio of the quarter-point moment to the center moment.

TABLE I—VALUES OF C IN THE EQUATION $m=CM$

(Ratio of quarter-point moment to center moment)

k	0.75	0.76	0.77	0.78	0.79	0.80
0.05	0.990	0.991	0.991	0.992	0.992	0.993
0.10	0.960	0.962	0.964	0.966	0.968	0.970
0.15	0.910	0.914	0.919	0.923	0.928	0.932
0.20	0.840	0.847	0.854	0.862	0.869	0.876
0.25	0.750	0.760	0.770	0.780	0.790	0.800
0.30	0.640	0.652	0.665	0.677	0.689	0.701
0.35	0.510	0.523	0.537	0.550	0.563	0.577
0.40	0.360	0.372	0.385	0.397	0.409	0.421
0.45	0.190	0.198	0.206	0.215	0.223	0.231

TABLE II—VALUES OF A AND B IN EQUATION $A=C+rB$

(All coefficients are positive except as indicated)

k	A	B	k	A	B
0.00	1.0000	0.0000	0.30	—0.2816	1.2288
0.05	0.9504	0.0528	0.35	—0.4896	1.3328
0.10	0.8064	0.2048	0.40	—0.5616	1.2288
0.15	0.5824	0.4368	0.45	—0.4256	0.8208
0.20	0.3024	0.7168	0.50	0.0000	0.0000
0.25	0.0000	1.0000			

TABLE III—VALUES OF r for double-headed railway locomotives

Span Feet	Cooper's E-Loading	Santa Fe 450 Ton	Mikado 400 Ton	Mountain 400 Ton
30	0.758	0.750	0.762	0.758
40	0.769	0.771	0.775	0.760
50	0.779	0.765	0.760	0.755
60	0.777	0.756	0.782	0.764
70	0.764	0.778	0.792	0.777
80	0.764	0.778	0.766	0.769
90	0.779	0.771	0.755	0.758
100	0.786	0.762	0.759	0.756
150	0.754	0.755	0.763	0.755
200	0.770	0.764	0.755	0.757
250	0.774	0.751	0.745	0.744

The given values of C may be verified, or additional values computed, from the coefficients in Table II, which gives the values of A and B in the equation

$$C = A + rB$$

where r is the ratio of the quarter-point moment to the center moment, and A and B are functions of k. The given values of A and B may be verified, or additional values computed, from the following equations:

$$A = 1 - 20k^2 - 64k^4$$

$$B = \frac{64}{3}(k^2)\ (1 - 4k^2)$$

As a guide to the proper value of r to assume for the design of railway spans, Table III is included. For a uniform load on the entire span the value of r is, of course, 0.750.

The foregoing method may be used for computing the live load moments at the panel points of truss spans, besides determining the lengths of cover plates of girder spans. For a 300-ft. span, the maximum error in live load moment is 2 per cent—THEODORE DOLL, *Structural Engineer, Kansas City, Mo.*

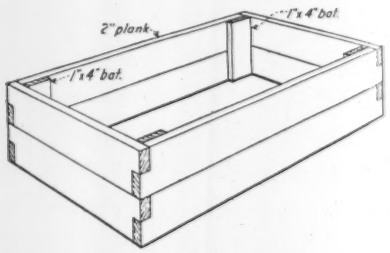
Creek Bottom Catchbasin At Mud Mountain Dam

A novel solution of a flood control problem is in use in Lower Cascade Creek, a small stream that flows into the canyon close to the center line of Mud Mountain Dam. As only a small drainage area is involved, the quantity of flow is small but complete diversion is essential because of construction going on in the deep canyon below.

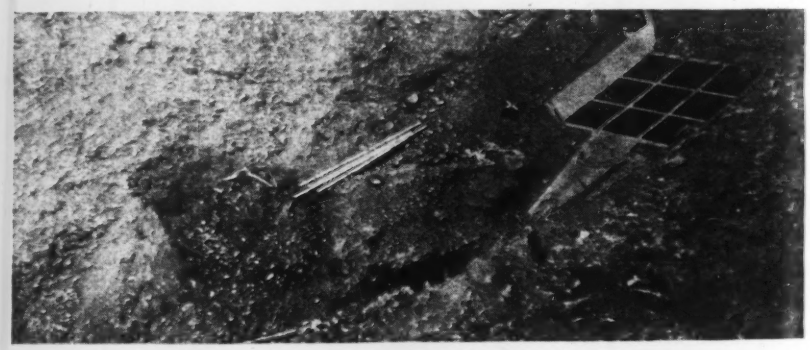
The solution was found in a concrete catchbasin 20 x 24 ft. in plan, excavated in the bottom of the stream bed and covered over with a grillage of ½ x 4-in. steel bars with ¾-in. clear spaces between them. These are arranged in nine square panels with sufficient total area to handle the stream's entire flow, even after a considerable portion of the barred area is choked with débris. A 12-in. pipe from the low portion of the basin is believed to be ample to carry off maximum flow. The steep slope of the grillage is expected to simplify removal of débris brought down by floods.

Sheathing for Small Pits

The accompanying sketch illustrates an easy method of cribbing small excavations in unstable soils. This method has proven very useful and economical for cribbing wells and small foundation excavations in the Columbia River Valley where the gravel soils will not stand alone. By

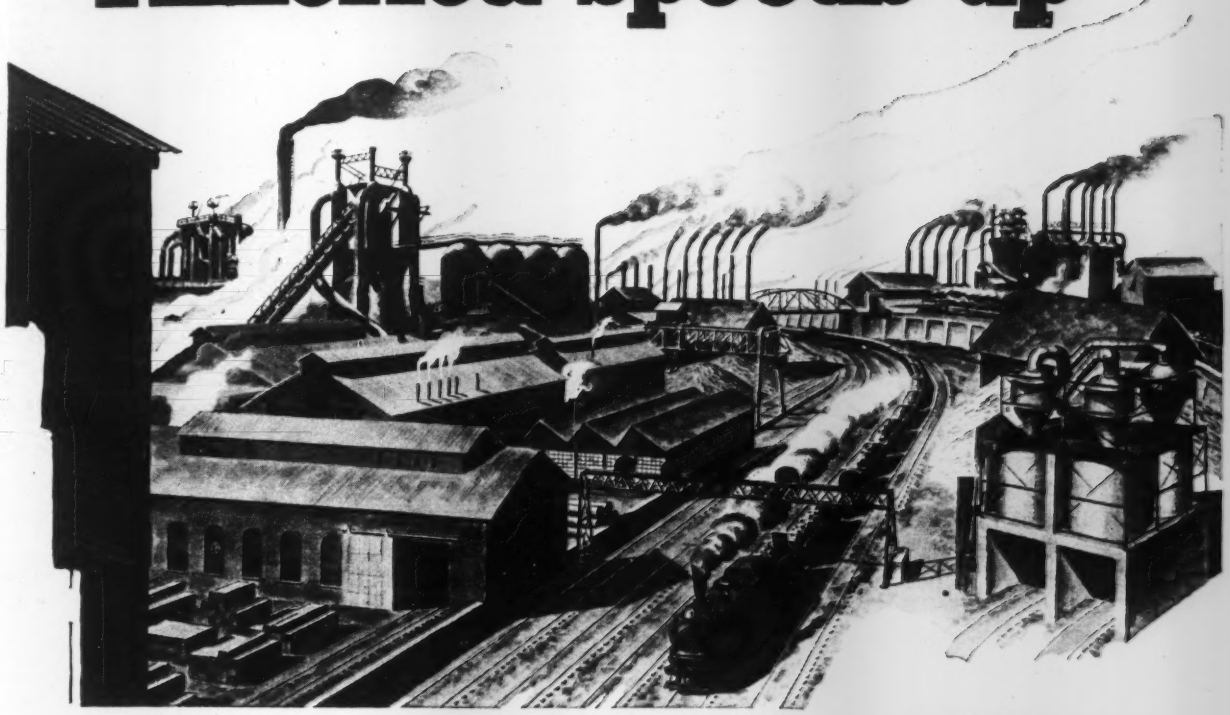


using the planks (precut as indicated) the cribbing may be started at the top and placed as the excavation goes down with very little loss of digging time. Wales and struts are eliminated as the dovetail arrangement enables this cribbing to withstand ordinary compression. Additional sections are hung from the preceding one by short bats cut just long enough to take one more section.—RICHARD H. WOOD, *Field Engineer, The Bonneville Project, White Bluffs, Wash.*

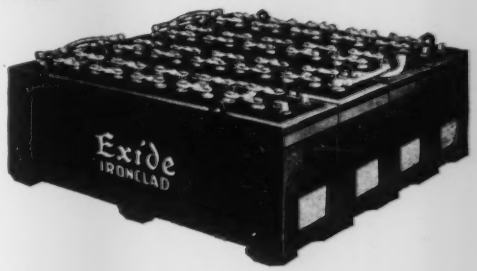


Catchbasin in bed of Lower Cascade Creek is drained by a 12-in. pipe, lower left. Slope of the surface is expected to simplify keeping rack clear.

America speeds up



. . . with batteries that can "take it" in underground haulage



Faster haulage speeds, and heavier loads of industry's basic materials produced by mine and quarry—both are needed underground today to meet the quickened tempo of manufacture and production. When locomotives or trammers are powered with Exide-Ironclads, you can call on them for more power and higher haulage speed with the certainty that these batteries will not fail you.

The outstanding quality of Exide-Ironclads is their dependability under the toughest conditions. Combined with high power ability and sustained voltage, Exide-Ironclad dependability enables you to haul more coal, ore, rock, or muck without paying a premium in short battery life or high battery maintenance.

Exide-Ironclads not only can deliver the increased performance you need, but they can stand up and "take it" when underground haulage speeds up. Write for free booklet, "The Storage Battery Locomotive for Underground Haulage."

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CONTRACT UNIT PRICES

What contractors are bidding on different kinds of construction work

RAILROAD AND HIGHWAY RELOCATION, MISSISSIPPI

OWNER: U. S. Engineer Office, Vicksburg, Miss.

PROJECT: Relocation of Illinois Central and Mississippi State Highway No. 7 across Sardis Reservoir, in Lafayette and Marshall Counties, Miss. Begins at point approximately 11 miles north of Oxford and extends 3½ miles in northerly direction. Work involves clearing, grading, grubbing, excavation, fills, sodding, paving, culverts, reinforced concrete and laying of track. Also includes construction of railroad and highway trestles and truss spans.

CONDITIONS: Contractor to furnish all materials except rails which will be provided by Illinois Central Railroad. Rail and highway transportation facilities available. Project to be completed in 400 working days. Wage rates on project are: skilled, 75c. to $1.00 per hr.; semi-skilled 40 to 50c.; and common, 30c. An alternate of 15-in. clay pipe was allowed for the concrete pipe specified; and a steel piling could be used for the highway trestle in place of timber piling. Award was made on basis of clay pipe, and steel piling for trestle.

BIDS: Thirteen bids were opened September 23, 1940, ranging from the contract low of $721,769 to $1,253,397.

LIST OF BIDDERS: On alternate basis noted above.

1. Robinson & Young, Baton Rouge, La. (contract) ... $721,769
2. Morton & Coleman, Inc., Memphis, Tenn. ... 797,814
3. C. J. List Constr. Co., Kansas City, Mo. ... 811,922
4. Keliher Constr. Co., Dallas, Tex. ... 821,515
5. E. J. Albrecht Co., Chicago, Ill. ... 843,112
6. John F. Bloomer, Appleton, Wis. ... 843,710
7. Kansas City Bridge Co., Kansas City, Mo. ... 886,502
8. Driver Contracting Co., and Wyatt L. Sharpe, Memphis, Tenn. ... 905,112
9. Forcum-James Co., Dyersburg, Tenn. ... 905,826
10. Hardaway Contracting Co., Columbus, Ga. ... 922,780
11. Hooper Constr. Co., Jacksonville, Fla. ... 1,010,706
12. Johnson & Greene and L. A. Davidson, Whitmore Lake, Mich. ... 1,072,610
13. Foley Bros., Inc., St. Paul, Minn. ... 1,253,397

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Clearing	13 ac.	$60.00	$100.00	$125.00
2. Grubbing	L.S.	1,000.00	500.00	1,500.00
3. Excavation, common	955,000 c. y.	.16	.23	.26
4. Rolled fill	760,000 c. y.	.05	.03	.04
5. Topsoil	1,800 c. y.	.50	1.00	.70
6. Strip sodding	66,000 s. y.	.07	.10	.06
7. Spot sodding	182,000 s. y.	.04	.03	.03
8. Highway pavement	36,000 s. y.	.35	.30	.30
9. Asphalt (cut back)	180,000 gal.	.10	.09	.10
10. Pile loading test	10 ea.	275.00	200.00	150.00
11. 15-in. concrete pipe	550 l. f.	2.00	1.90	2.35
12. *15-in. clay pipe	550 l. f.	2.00	2.25	2.15
13. 15-in. corr. metal pipe	800 l. f.	2.25	2.15	2.65
14. 18-in. corr. metal pipe	50 l. f.	3.00	2.55	2.95
15. 24-in. corr. metal pipe	50 l. f.	4.00	4.00	4.00
16. 36-in. concrete pipe	50 l. f.	6.00	6.00	6.00
17. 48-in. oval concrete pipe	40 l. f.	12.00	14.00	11.00
18. Culvert concrete	320 c. y.	22.00	25.00	21.00
19. Surfacing (pub. and priv. road grade crossings)	700 s. y.	.75	.60	.50
20. Conc. reinforcing steel	25,200 lb.	.045	.04	.04
21. Handling rails (main line)	28,000 l. f.	.04	.03	.04
22. Ties (main line)	8,600 ea.	1.41	1.50	1.25
23. Ballast (main line)	7,500 c. y.	2.90	3.40	2.33
24. Track laying and surf. (main line)	14,000 l. f.	1.15	1.15	1.15
25. Rails, handling (siding)	2,000 l. f.	.04	.03	.04
26. Ties (siding)	620 ea.	1.41	1.50	1.25
27. Ballast (siding)	250 c. y.	2.90	3.40	2.33
28. Track laying and surf. (siding)	1,000 l. f.	1.15	1.75	1.15
29. Remove existing track	17,000 l. f.	.25	.12	.13
30. Remove exist. trestle and temp. br.	3,200 l. f.	1.75	2.00	1.50
31. Remove exist. hwy. trestle	1,500 l. f.	1.50	2.00	1.30
32. Remove, reinstall signs	L.S.	90.00	100.00	100.00
33. Right-of-way fence	14,000 l. f.	.075	.40	.08
34. Slope paving	5,500 s. y.	2.00	3.00	2.75
35. Field office	L.S.	3,000.00	2,500.00	3,000.00
36. Tr. timber piling, hwy. trestle	17,300 l. f.	1.15	1.50	1.35
37. Tr. timber bracing	28 Mbm.	150.00	160.00	167.00
38. Tr. timber caps	19 Mbm.	150.00	180.00	148.00
39. Steel, structural	514,000 lb.	.049	.05	.047
40. Concrete	1,330 c. y.	23.00	27.00	23.00
41. Steel, conc. reinforcing	306,000 lb.	.041	.04	.04
42. Handrail	3,400 l. f.	1.75	2.00	1.60
43. *Steel H-piling, hwy. trestle	15,000 l. f.	1.40	1.70	1.80
44. *Steel, structural	506,000 lb.	.049	.05	.052
45. *Concrete	1,550 c. y.	23.50	27.00	25.25
46. *Reinforcing steel	351,000 lb.	.041	.04	.04
47. *Handrail	3,400 l. f.	1.75	2.00	1.60
48. Struc. excav., hwy. truss spans	7,300 c. y.	2.00	2.00	2.40
49. Backfill	6,700 c. y.	.25	.40	.15
50. Untr. timber piling	5,000 l. f.	.65	.60	.80
51. Concrete in piers	750 c. y.	23.00	18.00	20.50
52. Concrete in floor	265 c. y.	23.00	27.00	23.00
53. Reinforcing steel	105,000 lb.	.0425	.04	.04
54. Structural steel	485,000 lb.	.0767	.085	.0725
55. Remove exist. truss and piers	L.S.	2,500.00	3,750.00	3,000.00
56. Struct. excav., railroad trestle	265 c. y.	1.00	1.00	1.00
57. Backfill, RR trestle	190 c. y.	.50	.40	.15
58. Treated timber piling	41,000 l. f.	1.15	1.40	1.30
59. Tr. timber caps and stringers	204 Mbm.	145.00	150.00	162.00
60. Tr. timber bracing and flooring	185 Mbm.	135.00	135.00	140.00
61. Rails, handling (main line)	3,350 l. f.	.05	.03	.04
62. Ties	1,020 ea.	2.25	1.50	1.25
63. Ballast	560 c. y.	3.25	4.00	3.25
64. Track laying and surfacing	1,675 l. f.	1.15	1.25	1.15
65. Water barrels	11 ea.	10.00	20.00	5.00
66. Concrete in fire walls	180 c. y.	25.00	20.00	21.00
67. Reinforcing steel	7,300 lb.	.0425	.04	.04
68. Excav., struct., RR truss spans	8,600 c. y.	2.00	2.00	2.40
69. Backfill, RR truss spans	7,400 c. y.	.25	.40	.15
70. Untr. timber piling	7,400 l. f.	.65	.60	.80
71. Concrete in piers	2,050 c. y.	20.00	15.00	16.50
72. Reinforcing steel	41,000 lb.	.041	.04	.04
73. Erection of structural steel	L.S.	17,500.00	15,500.00	15,000.00
74. Rails, handling (main line)	760 l. f.	.06	.05	.04
75. Ties	390 ea.	3.50	4.20	3.00
76. Track laying and surfacing	380 l. f.	1.40	1.50	1.00
77. Tr. timber guard rails	750 l. f.	.50	.70	.50

* *Alternate*

WATERMAINS, WASHINGTON

OWNER: Board of Public Works, Seattle, Wash.; C. L. Wartelle, city engineer.

PROJECT: Construction of 10,412 feet of 8-in. Class 150 cast iron watermains, 16th Avenue N.E. and other streets in that vicinity in Seattle, Wash. Gate valves, valve chambers and hydrants already in place in established system must be moved during course of present construction.

CONDITIONS: Highway transportation facilities available. Contractor to furnish all materials except gate valves, valve chambers and hydrants already in place. Work to be completed in 90 days. Wage rates stipulated are: skilled labor, $1.85 per hr.; semi-skilled, $1.25; and common, $1.00.

BIDS: Four bids were received October 17, 1940, ranging from the contract low of $30,735 to $35,770.

LIST OF BIDDERS:

1. Valley Constr. Co., Seattle, Wash. (contract) ... $30,735
2. Queen City Constr. Co., Seattle, Wash. ... 32,144
3. Superior Constr. Co., Seattle, Wash. ... 35,216
4. Argentieri & Colarossi, Seattle, Wash. ... 35,770

Item	Quan.	Unit Prices (1)	(2)	(3)
1. Cl. 150 8-in. c. i. watermains	10,412 l. f.	$1.94	$2.05	$2.35
2. Move 8-in. gate valves	4 ea.	5.00	20.00	45.00
3. Valve chamber, existing ring and cover casting	4 ea.	50.00	40.00	70.00
4. Valve chamber, rebuilt	8 ea.	50.00	30.00	40.00
5. Fill existing valve chamber	4 ea.	5.00	5.00	10.00
6. Reset existing hydrants	36 ea.	15.00	20.00	25.00
7. Hydrant drain	100 l. f.	.25	.50	.40
8. Shackle rods	350 lb.	.18	.15	.15
9. 6-in. c. i. pipe, cl. 150, hydrant conn.	80 l. f.	2.00	1.50	1.75
10. Creosoted wood blocking	0.1 M b.m.	100.00	100.00	80.00
11. Concrete blocking	2 c. y.	18.00	12.00	10.00
12. 2-in. galv. steel pipe	895 l. f.	.65	.85	.60
13. 2-in. gate valves	2 ea.	14.00	15.00	10.00
14. Cast iron valve boxes	2 ea.	9.00	11.00	20.00
15. Conn. at 16th Ave., N. E. and E. 52d St.	1 ea.	200.00	200.00	50.00
16. Conn. at 17th Ave. N. E. and E. 55th St.	1 ea.	200.00	200.00	200.00
17. Extra excavation	100 c. y.	2.00	2.00	1.50
18. Gravel in place, except rdwy.	16 c. y.	2.00	3.00	3.00
19. Plank crossings	6 M b.m.	10.00	20.00	25.00

SPEEDING HIGHWAY 'REARMAMENT'

AVOID WINTER SLOW-DOWN, CUT COLD-WEATHER COSTS, WITH 'INCOR' 24-HOUR CEMENT

"ADEQUATE highways rank in importance with the soldier and his weapons in national defense." This policy underlies a far-reaching highway improvement program—building new roads, widening existing highways, strengthening bridges.

Speed Winter Work

Speed is the order of the day . . . it is essential to make every week count this winter . . . no time now for the usual cold-weather slow-down.

Use 'Incor' 24-Hour Cement to assure normal construction speed, even in sub-freezing weather. U. S. Route No. 40 (above), near Putnamville, Ind., is one of hundreds of important winter jobs where 'Incor' prevented an expensive cold-weather slow-down.

Cut Cold-Weather Costs

By hardening thoroughly in one-third the usual time, this improved Portland cement minimizes freezing risk, cuts heat-protection costs by 50 to 60 percent, saves two to five days on each pour.

Act now to save vital weeks this winter. Use 'Incor'* for highways and bridges, new factories and plant additions, air and naval bases. 'Incor' is a cold-weather safety factor, proved by over 13 years' outstanding performance. Write for copy of "Cold-Weather Concreting." Lone Star Cement Corporation, Room 2290, 342 Madison Avenue, New York.

*Reg. U. S. Pat. Off.

LONE STAR CEMENT CORPORATION

MAKERS OF LONE STAR CEMENT . . . 'INCOR' 24-HOUR CEMENT

WE PRE-TESTED IT FOR YOU—15,000 Hours!

HERE'S YOUR REPORT—
AVAILABILITY 98%
MAINTENANCE ON FLEXOMOTIVE DRIVE . . . NONE
REPAIRS . . . . . NONE
JOBS . . HAULING, SWITCHING (Others?)

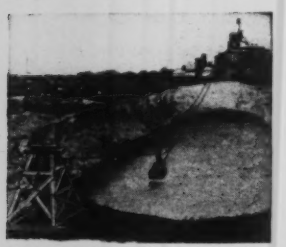
NOW WE GIVE YOU A REAL GUARANTEE . . . an unqualified, written performance guarantee you can get with no other locomotive. Write for the complete story of FLEXOMOTIVE—newest, most economical, most flexible source of abundant power.

write
PLYMOUTH LOCOMOTIVE WORKS
Division of Fate-Root-Heath Co.
PLYMOUTH, OHIO

Plymouth FLEXOMOTIVE
GIVES YOU EVERYTHING YOU WANT IN A LOCOMOTIVE!

IN DRY GROUND . . . OR UNDER WATER

SAUERMAN Power Drag Scraper moving 35 loads per hour over a 400-foot operating span.



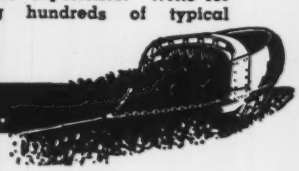
SAUERMAN Cableway moving dry and wet gravel to top of screening plant for a few cents per cubic yard.

dig, haul & dump
. . . . for a few pennies a yard!

SAUERMAN Long Range Equipment digs and delivers economically because:

- Comparatively low cost installation.
- Materials handled are delivered in a straight line operation ANYWHERE up to 1500 feet.
- Eliminates all re-handling—three operations in one efficient movement.
- Ease of operation—machines effectively run with little practice.
- Entirely operated by one man.
- Power cost and maintenance expense are exceedingly low.

Our engineers are always freely at your service to give advice and suggest cost-reducing methods based on their 30 years' experience. Write for our catalog showing hundreds of typical Sauerman jobs.



SAUERMAN BROS., Inc.
432 S. CLINTON ST., CHICAGO, ILLINOIS

MEN AND JOBS

MAJ. MATTHEW R. BEEBE, Corps of Engineer Reserves, and maintenance engineer for the Construction Service, Veterans Administration, Washington, D. C., has been appointed to one year's active duty in the regular army. Maj. Beebe will be stationed initially at Indiantown Gap, Pa., National Guard Camp, as post engineer.

BURTON J. BELL, paving engineer with the U. S. Engineers at the Washington National Airport, Washington, D. C., has been transferred to the naval air station, Norfolk, Va. At Norfolk he will work as paving engineer for the large defense program being carried out by the Virginia Engineering Co., Inc.

RALPH H. CHAMBERS, formerly vice president of the Jarrett-Chambers Co., New York City, and later vice president of The Foundation Co., New York, and for some years after that consulting engineer in private work, has been appointed vice president and director of The Foundation Co.

WILLIAM BENJAMIN GREGORY, professor emeritus of experimental engineering and hydraulics at Tulane University, received the Worcester Reed Warner Medal at the recent 61st annual meeting of the American Society of Mechanical Engineers in New York. Gregory, a member of the engineering faculty at Tulane for 44 years prior to his retirement in 1938, served as consultant on hydraulic problems to the U.S. Engineers, the Louisiana State Board of Engineers, and many municipalities and private firms.

ROSS M. KEARNS, chief construction engineer for Montgomery Ward & Co., has resigned and will become chief engineer of the construction department of W. T. Grant & Co., New York City.

LAWRENCE T. SMITH, designing and construction engineer for the Chicago Park District, has been called into active service as captain in the Corps of Engineers and has been temporarily assigned as intelligence officer at Camp Grant, Ill.

R. W. DENNIS, area engineer with the state WPA office at Mitchell, S. D., has resigned to accept a civil service appointment as engineering draftsman with the Bonneville power commission and will be located at Portland, Oregon.

RALPH M. PALMER, assistant construction engineer for the city of Duluth since 1923, has been named superintendent of

(*Continued on p. 74*)

Koehring invites you to come to the

38th ANNUAL

ROADS for DEFENSE

ROAD BUILDERS CONVENTION

PENNSYLVANIA HOTEL
NEW YORK CITY

JAN. 27-31
1941

KOEHRING HEAVY DUTY

HEAVY-DUTY CONSTRUCTION EQUIPMENT

MATERIALS AND LABOR PRICES

Market quotations on construction materials and wage rates reported monthly by ENR correspondents

LUMBER AGAIN provides the most important price change in the construction material price list for January, 1941. Short Leaf Yellow Pine is up 50c. to $1.00 in Cleveland; up $1.00 to $4.50 in Kansas City; and up 50c. to $1.00 on 2-in. sizes in Chicago. Spruce and Roofers' Pine is up $3.00 to $6.00 in Boston. Native Pine is up $2.00 in Denver. Spruce is $2.00 higher in Montreal. Douglas Fir prices are $3.00 to $5.00 higher on most sizes in Boston; up $1.50 to $4.50 in Kansas City; up $1.50 in Montreal; and $2.00 higher in Seattle.

Cement is off 5c. per barrel in New York, but unchanged throughout the rest of the list. Paving asphalt dropped 50c. per ton in Cleveland, but is up $1.00 in Seattle.

Structural steel shapes are up 15c. per 100 lb. in San Francisco. Rail steel reinforcing bars are 5c. per 100 lb. higher in Boston. Roofing supplies are up in Baltimore, Boston and Montreal, but lower in Dallas.

Common labor wage rates are unchanged from December levels, but skilled rates seem to be softening in Baltimore, Los Angeles and St. Louis. Carpenters former rate of $1.375 in Boston now ranges from $1.00 to $1.25; Carpenters Los Angeles rate, $1.10 is off 2½c.; and the St. Louis rate of $1.50 now ranges from $1.00 to $1.50. Structural ironworkers rate is $1.50 in Boston, down 12½c. per hr. The range from $1.375 to $1.625 which prevailed for hoisting engineers in Boston has now closed up, with the higher rate now prevailing.

CEMENT, AGGREGATES, READY-MIXED CONCRETE—F.O.B. CITY

	PORTLAND CEMENT			SAND AND GRAVEL			CRUSHED STONE		CRUSHED SLAG		CONCRETE
	Per bbl., carload lots, including 40c per bbl. for bags, cash discount not deducted			Per ton, carload lots			Per ton, carload lots		Per ton, carload lots, f.o.b. plant		Ready Mixed 1:2:4, 50 c.y. or more, delivered
	Cloth Bags *a*	Paper Bags	Bulk	Gravel, 1½ in.	Gravel, ¾ in.	Sand	1½ in.	¾ in.	1½ in.	¾ in.	
Atlanta	$2.90	$2.66	$2.61	$1.75	$1.85	$1.95	$1.65	$1.75	$1.55	$1.65	$7.90
Baltimore	2.31	2.06	1.86	1.75‡	1.75‡	1.25‡	1.75‡	1.75‡	1.75‡	1.75‡	6.75
Birmingham	2.50	2.25	2.05	1.75	1.75	1.50	1.00	1.00	.90	1.15	5.80
Boston	2.75*b*	2.50*b*	2.30	1.20‡	1.20‡	.90‡	1.20‡	1.20‡	....	....	6.75*m*
Chicago	2.60	2.35	2.20	2.00‡*d*	2.00‡*d*	2.00‡*d*	2.00‡*d*	2.00‡*d*	1.25‡	1.25‡	....
Cincinnati	2.58	2.33	2.08	1.20	1.20	1.10	1.80	1.80	....	....	6.60
Cleveland	2.60	1.75	....	1.45*i*	1.45*i*	1.30*i*	1.70*i*	1.70*i*	1.70*i*	1.70*i*	6.55*i*
Dallas	2.47	2.22	2.02	1.75*p*	2.00*p*	1.25*p*	1.69*p*	1.84*p*	....	....	6.20
Denver	3.08	2.83	....	1.20	1.40	.90	....	....	....	....	7.25
Detroit	2.24	1.99	1.79	1.55	1.65	.95	1.55	1.65	1.30‡	1.40‡	6.75
Kansas City	2.56	2.31	2.16	1.85	2.30	1.00	1.91	1.91	....	....	7.25*n*
Los Angeles	2.25*b*	2.05*b*	....	1.00	1.00	1.00	1.00*f*	1.00*f*	....	....	5.85
Minneapolis	2.90	2.65	....	1.00*h*	1.00*h*	.25*h*	1.00*h*	1.00*h*	....	....	7.60*j*
Montreal	....	1.82*r*	1.67*r*	....	....	1.25‡	.85‡*c*	1.00‡*c*	....	....	6.48*l*
New Orleans	2.41	2.16	1.96	1.50	1.50	1.25	....	....	....	....	7.25
New York	2.55‡	2.30‡	....	1.25*de*	1.25*de*	.75*de*	1.65*de*	1.75*de*	....	....	6.50
Philadelphia	2.32	2.07	1.87	1.55‡	1.65‡	1.25‡	....	....	1.00	1.00	7.95*k*
Pittsburgh	2.44	2.19	1.99	1.40‡	1.40‡	1.70‡	2.25‡	2.25‡	1.50	1.50	7.50
St. Louis	2.55	2.30	....	1.50‡	1.50‡	1.25/1.50‡	.90*h*	.90*h*	.75*g*	.75*g*	7.50
San Francisco	2.16	1.96	1.66	1.36	1.36	1.36	1.46	1.46	....	....	6.95
Seattle	2.95*o*	2.70*o*	....	1.00*o*	1.00*o*	1.00*o*	2.00*o*	2.00*o*	....	....	7.25

‡ Delivered. *a* 10c. allowed for each returnable bag. *b* 10c. per bbl. off for cash. *c* Plus municipal tax. *d* Per cu. yd. *e* Barge lots alongside docks. *f* Crushed granite. *g* F.o.b. Granite City, Ill. *h* F.o.b. plant. *i* Within three miles of Public Square. *j* 5% discount for cash. *k* Discount 35c. 500 to 2000; 70c. 2000 to 5000; 95c. over 5000. *l* Up to 200 cu. yd. *m* 50c. off for cash. *n* 25 c.y. or more. *o* 2% off for cash. *p* 10c. per ton off, cash 15 days. *r* 10c. per bbl. off, cash 20 days.

CASH DISCOUNTS CEMENT to Contractors: truck delivery. 2% for cash on 10th of month; on carload deliveries, no trucking, same as dealer cash discount 10c. per bbl. for payment within 15 days of date of invoice. Subject discount 10c per bbl. 20 days in Montreal.

CURRENT MAXIMUM PRICES RECEIVED AT CEMENT MILL

Charge for bags not included. For cloth bags, add 40c. per bbl.; 10c. refund allowed for each returnable bag; for paper bags add 15c. per bbl., not refundable.

	Bagged	Bulk		Bagged	Bulk		Bagged	Bulk
Buffington, Ind.	$1.70	$1.65	Ironton, Ohio	$1.60	$1.55	Richard City, Tenn.	$1.80	$1.75
Dallas, Tex. (Inc. 5c. tax)	1.80	1.75	Limedale, Ind.	1.70	1.65	Steelton, Minn.	1.80	1.75
Hannibal, Mo.	1.70	1.65	Norfolk, Va.	1.65	1.60	Universal, Pa.	1.65	1.60
Hudson, N. Y.	1.75	1.70	Northampton, Pa.	1.55	1.50	Waco, Tex. (5c. tax in Tex.)	1.75	1.70
Independence, Kans.	1.70	1.65	North Birmingham, Ala.	1.70	1.65	Montreal	1.55	1.55

PAVING BRICK, BLOCKS, ASPHALT, ROAD OILS—F.O.B. CITY

	PAVING BRICKS AND BLOCKS			PAVING ASPHALT		ASPHALT BINDERS—FLUXES		CUTBACK ASPHALT		ROAD OILS	ASPHALT EMULSION (Quick-breaking)
	Granite per M. lots of 50,000 4x4x8 in.	Brick per M. 3-4x8½ in. carload lots	Wood per sq. yd. 3½ in. 16-lb. treat	Per ton, less than 80 penetration		Per gal., 80-300 penetration		Per ton		Per gal.	Per gal.
				Tank car	Drums	Tank car	Drums	Tank car	Drums	Tank car	Tank car	Drums
Atlanta	$73.00	$39.35	$2.25	$17.30*e*	$23.83*e*	$0.0695*e*	$0.1018*e*	$0.0734*he*	$0.1257*h*	$0.0634*e*	$0.0734	$0.1257
Baltimore	150.00‡	45.00‡	2.75	14.00	20.00	.06	.09	.065*h*	.115*h*	.....	.....	.....
Birmingham	.....	27.50*f*‡	....	18.20	23.20	.0747	.1047	.0834*h*	.1484*h*	.....	.....	.....
Boston	85.00	47.50	3.00	14.00	20.00	.06	.09	.065*h*	.115*h*	.065	.09‡	.12‡
Chicago	135.00	45.00	1.85*d*	14.50	18.50	13.00*g*	17.00*g*	.06*h*	.09*h*	.04	.09	.125
Cincinnati	112.00	37.50	....	13.50	17.50	.07	.....	16.80	.....	.0525	.....	.075
Cleveland	110.00	37.50	2.80	15.00	20.00	.065	.075	.075*h*	.085*h*	.035	.08	.09
Dallas	.....	30.00	....	13.25	20.30	.06	.103	15.00	24.80	.055	.05/.07	.07/.09
Denver	.....	27.50	....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Detroit	.....	35.00	....	13.15*f*	18.45*f*	.061	.0984	13.15	17.20	.0475	.061	.0923
Kansas City	.....	40.00	....	18.50	23.50	.077	.1075	.077*h*	.107*h*	.057	.11	.15
Los Angeles	.....	50.00	....	6.50*b*	15.00	6.50*bg*	15.00*bg*	5.50*b*	.....	.0192	.0525	.1125
Minneapolis	.....	.....	1.90*d*	19.20	24.20	.10	.12	19.30	28.30	.056	.....	.....
Montreal	75.00	.....	3.62	16.60	24.25	.116	.1483	.115*h*	.135*h*	.08	.135	.188
New Orleans	.....	.....	....	14.00*a*	19.00*a*	.055	.085	.06*h*	.09*h*	.....	.078	.....
New York	.....	.....	2.90	15.00	21.00	.06	.09	.065*h*	.115*h*	.....	.07	.11
Philadelphia	120.00	42.50	2.84	14.00	19.00	.055	.08	.06*h*	.09*h*	.05	.06	.09
Pittsburgh	135.00	38.75	....	.....	.....	.....	.....	.....	.....	.....	.....	.....
St. Louis	110.00/121.00	37.00	....	14.00	19.00	14.00*g*	19.00*g*	.06*h*	.095*h*	.04	.09	.125
San Francisco	.....	70.00	....	6.50	15.00	6.50*g*	15.00*g*	7.00	17.50	.025	.0525	.1125
Seattle	.....	60.00*c*	....	15.70	25.10	.....	24.10*g*	10.50/11.50	24.00/25.00	8.85*g*	.0575*i*	.1308*i*

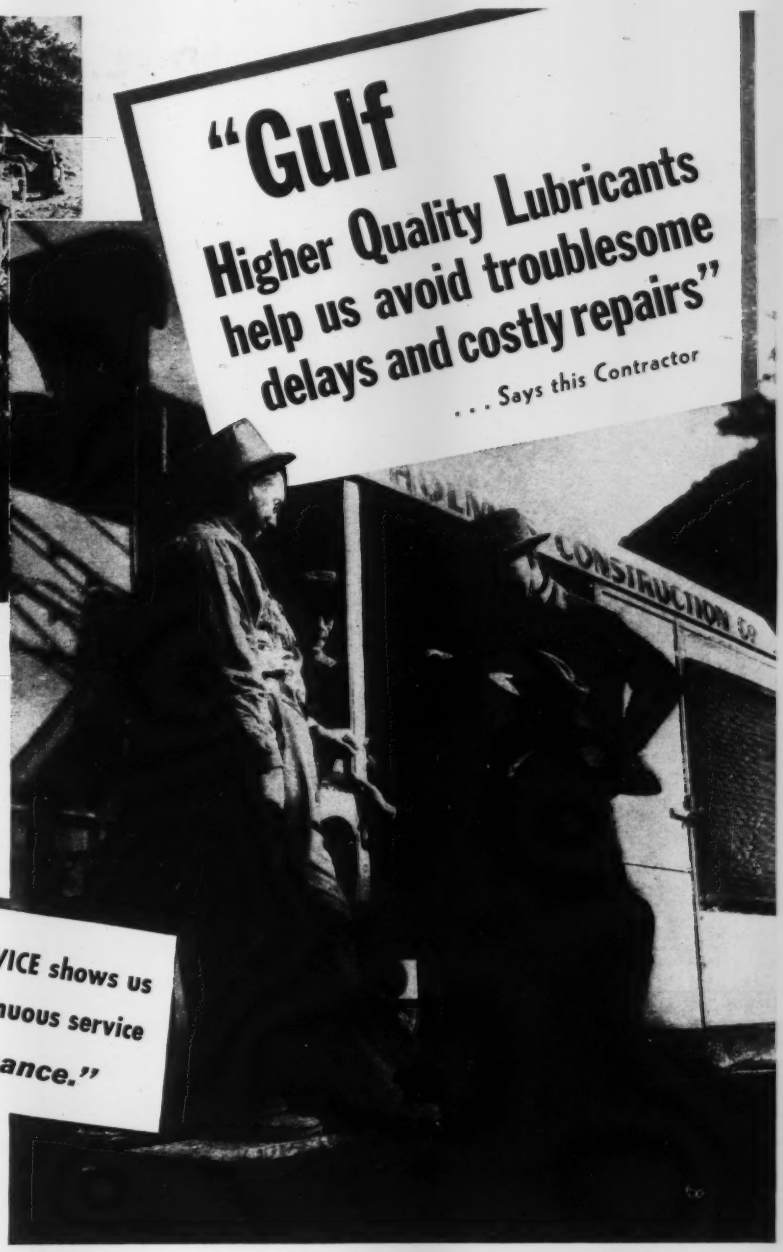
‡ Delivered. *a* F.o.b. Baton Rouge. *b* Delivered to purchaser's warehouse. *c* 3½x4x8½ in. *d* 2½ in. 6 to 8-lb. treatment. *e* Local reduction due to 20% reduction intra-state class freight rates, only Georgia affected. *f* Mexican. *g* Per ton. *h* Per gallon. *i* F.o.b. Martinez. *j* 3x3¾x8½ in.

"Our Diesels have gone well over 4,000 hours without replacements since we standardized on Gulf's higher quality lubricants," *says Contractor.*

(At right) Discussing a lubrication problem with men on the job, is one of the beneficial services rendered by the Gulf Engineer.

"Gulf Higher Quality Lubricants help us avoid troublesome delays and costly repairs"

. . . Says this Contractor



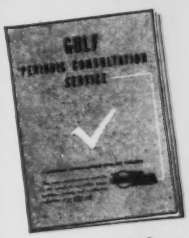
"GULF PERIODIC CONSULTATION SERVICE shows us how to keep our equipment in continuous service with less cost for maintenance."

"THE profit on any contracting job depends on the speed and efficiency of the equipment that does the work," says this Contractor. "That's why we use Gulf higher quality lubricants—we can always depend on the extra margin of safety we get when we have these fine lubricants in service."

Contractors all over the country rely on the extra stability of Gulf's higher quality lubricants. They do the kind of lubricating job that means less cost for maintenance and repairs — and long life for expensive machinery and equipment.

Call in a Gulf Engineer when you start your next job. Find out how GULF PERIODIC CONSULTATION SERVICE can help you cut costs. Write or phone your nearest Gulf office—there's no obligation.

Gulf's higher quality oils and greases are quickly available through more than 1100 warehouses in 30 states from Maine to New Mexico.



This booklet will suggest to you a practical method by which you can reduce operating and maintenance costs for your equipment. Write for your free copy.

Holmes-Construction Company, Wooster, Ohio depend upon Gulf's higher quality lubricants for all their equipment on this road construction job in Venango County, Pennsylvania.

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Address .....

IRON AND STEEL PRODUCTS—BASE MILL PRICES

	STRUCT. SHAPES-PLATE	REINF. BARS ¼-in. billet *b*	RIVETS ½-in. structural	WIRE NAILS Base *d*	SHEET PILING Base	STEEL RAILS Per Gross Ton			TRACK SUPPLIES			
						Standard	Light	Re-rolled	Angle Bars	Std. Spikes *c*	Tie Plates *c*	Tr. Bolts
Birmingham	$2.10	$2.15	$3.40	$2.55	.....	$40.00	$40.00	$39.00	$2.70	$3.00	$2.15	$4.1
Chicago	2.10	2.15	3.40	2.55	$2.40	40.00	40.00	39.00	2.70	3.00	2.15	4.1
Pittsburgh	2.10	2.15	3.40	2.55	2.40	40.00	40.00	39.00	2.70	3.00	2.15	4.1
Buffalo	2.10	2.15	.....	.....	2.40	.....	.....	.....	.....	.....	2.15	...
Cleveland	2.10	2.15	3.40	2.55	.....	.....	.....	.....	.....	.....	.....	...
Youngstown	.....	2.15	.....	.....	.....	.....	.....	.....	.....	3.00	.....	...
Detroit	.....	2.25‡	.....	.....	.....	.....	.....	.....	.....	.....	.....	...
Gulf ports	2.45*a*	2.50*a*	.....	.....	2.85*a*	.....	.....	.....	.....	.....	.....	...
Pacific ports	2.75*a*	2.55*a*	.....	.....	2.95*a*	.....	.....	.....	.....	.....	2.30	...

‡ Delivered. *a* F.o.b. cars dock. *b* Rail steel same as billet prices. Steelton, Pa., on spikes alone, Lebanon, Pa., Richmond, Va. *d* Add switching charge $18 per o.l.
c Other basing points include Portsmouth, O., Weirton, W. Va., St. Louis, Kansas City, Minnequa, Colo., and Pacific coast ports, on tie plates, alone,

IRON AND STEEL PRODUCTS—F.O.B. WAREHOUSE, PER 100 LB., BASE PRICE

	STRUCTURAL SHAPES Per 100 lb. base price	REINFORCING BARS* Per 100 lb., ¼ in., base price 15 tons or over *b* New billet	Rail steel	Add Switch	$/cwt. for Del.	EXPANDED METAL LATH—Per 100 sq.yd., carload lots— Std. diamond mesh, 3.4 lb.	Std. ribbed 3.4 lb.	WELDED FABRIC REINFORCING—Per 100 s.f., carload lots— 4x16 in., No. 5 & 10 wires	4x12 in., No. 8 & 12 wires	6x6 in. No. 6 & 6 wires Per sq. yd.	SHEET PILING Per 100 lb. base price
Atlanta	$2.34	$2.39	$2.14	.02½	.10	$21.00	$23.00	$1.82	$1.35	$0.1719	$3.01
Baltimore	3.70	2.90	2.75	.....	.10	24.00	26.00	1.70	1.27	.1611	2.90
Birmingham	2.10*a*	2.15	2.15	.02½	.10	20.50	22.50	1.80	1.34	.1701	....
Boston	3.85	2.61	2.51	$20 C.L.	.10	22.00	24.00	1.76	1.31	.1656	2.77
Chicago	2.10*a*	2.15	2.05	.03	.05	20.00	22.00	1.67	1.25	.1575	2.40
Cincinnati	3.68	2.46*c*	2.36*c*	.....	.05	20.50	22.50	1.66	1.25	.1566	...
Cleveland	3.58*g*	2.15	2.05	.02½	.10	22.50	23.50	1.66	1.25	.1566	....
Dallas	4.60	3.25	3.25	.....	.....	22.50	24.50	1.93	1.42	.1827	...
Denver	4.35	3.95	3.80	.....	.....	23.50	25.50	1.97	1.45	.1863	....
Detroit	3.60‡	2.25	2.15	.....	.10	22.50	24.50	1.68	1.26	.1584	2.66
Kansas City	4.00	2.51*c*	2.36*c*	.0	.05	15.50	19.00	1.78	1.33	.1683	2.86
Los Angeles	3.65*f*	2.25	2.10	.02½	.05	23.00	27.50	1.93	1.42	.1827	3.65
Minneapolis	3.80‡	2.48*c*	2.33*c*	.0	.10	19.50/20.50	21.50/22.50	1.80	1.34	.1701	2.734
Montreal	3.90	2.65	2.55	.....	.....	.....	.....	2.58	3.22	.264	2.58
New Orleans	4.40	2.52	2.52	.05	.10	21.50	23.50	1.82	1.35	.1719	2.875
New York	3.75	2.39	2.29	.....	.10	14.50	16.50	1.76	1.32	.1665	2.74
Philadelphia	3.55	2.66	2.56	.....	.....	19.50	21.50	1.71	1.28	.1611	2.72
Pittsburgh	2.10*a*	2.15	2.05	.02½	.10	21.50	24.50	1.59	1.20	.1503	2.40
St. Louis	3.47	2.39	2.29	.0	.05	24.00	28.00	1.69	1.27	.1602	2.70
San Francisco	3.50	2.50	2.35	.02½	.10	19.00	25.50	1.93	1.42	.1827	3.25
Seattle	2.75*e*	2.50*e*	.....	.....	.....	25.50	27.50	1.93	1.42	.1827	2.95*e*

‡ Delivered. *c* Mill prices. *b* 5–15 tons, add 15c. 1–5 tons, add 25c. Less than 1 ton, add 50c. *c* 20 tons or over Base. *d* Mill price plus freight. *e* F.o.b. dock. *f* Includes delivery in free delivery zone. *g* Less than 1 ton, add 30c.; 1 to 5 tons, add 10c. High scrap steel prices cut former 15c. differences between new billet and rail steel in many mills.

PLUMBING, HEATING, WATER, SEWER AND DRAIN PIPE

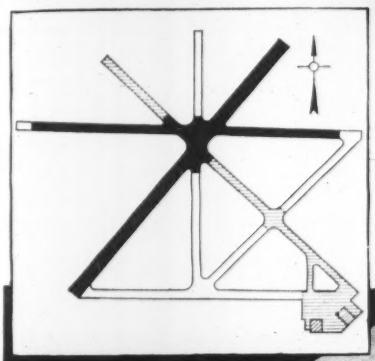
	C. I. PIPE	VITRIFIED SEWER PIPE				CLAY DRAIN TILE		CONCRETE SEWER PIPE		WROUGHT STEEL PIPE Full standard weight, *h*			
	Per net ton f.o.b. 6 in. to 24 in.*a*	Per foot, std. 8 in., e.s.	delivered std. 12 in., e.s.	ASTM 24 in.,	C13–35 36 in.,	Per 1,000 ft., carload lots, f.o.b. 6 in.	8 in.	Per ft., delivered; ASTM 12 in.	C 14–35 24 in.	1 to 3 in., Black %	Galv. %	Butt Weld 3½ to 6in.; Black %	Lap Weld Galv. %
Atlanta	$49 40	$0.26*b*	$0.468*bc*	$1.8525	$4.68*c*	$85.00	$128.00	$0.45	$1.642	62.2	54.2	59.7	51.2
Baltimore	52.80	.35	.60	2.30	6.80	115.00	150.00	.55	1.85	65.5	57.5	63.00	54.5
Birmingham	45.00	.26	.468	1.7875	4.66	85.00	220.00	.40	1.60	62.2	54.2	59.7	51.2
Boston	55.00	.203	.3645	1.98	5.64	133.50‡	223.50‡	.45	2.00	64.1	56.1	61.6	53.1
Chicago	53.80	.28	.54	2.25	6.25	100.00‡	150.00‡	.38	1.48	67.0	59.0	63.5	55.0
Cincinnati	52.70	.245	.4995	1.9335	5.6375	105.00	170.00	.60	1.70	65.9	57.9	63.4	54.9
Cleveland	54.24	.196	.378	1.485	4.51	69.00	108.00	.35	1.50	67.8	59.8	65.3	56.8
Dallas	58.20	.28	.504	2.016	4.70	80.00	100.00	.46	1.57	59.9	51.9	57.3	48.3
Denver	60.60	.24†	.52†	2.16†	.....	130.00	240.00	....	....	58.4	50.4	55.7	47.2
Detroit	54.24	.245	.4725	1.935	4.408	66.45	105.00	.33	1.50	66.3	58.3	63.8	55.3
Kansas City	55.12	.30	.54	2.16	5.00	120.00	240.00	.45	1.60	62.9	54.9	60.0	51.5
Los Angeles	55.00	.282†	.508†	2.034†	5.085†	115.50	192.50	1.00	2.00	59.6	51.6	57.0	48.6
Minneapolis	57.20	.24†	.432†	1.728†	4.60†	.....	.....	.70	1.80	64.2	56.2	60.7	52.2
Montreal	60.00	.55	.90	3.68	5.95*e*	135.00‡	260.00‡	.48	1.92	.....	.....	.....	....
New Orleans	51.38	.26	.48	1.69	.....	150.00	220.00	.37	2.10	62.4	54.4	58.8	50.3
New York	52.20	.30	.61	2.30	5.90	.....	.....	.50	1.20	64.9	56.8	62.4	53.9*i*
Philadelphia	50.90	.....	.....	.....	.....	.....	.....	.54	1.80	65.3	57.3	62.8	54.3
Pittsburgh	55.60	.245†	.4725†	1.845†	5.4325	97.80	154.20	.85*g*	2.00*g*	68.5*i*	60.5*i*	66.0*i*	57.5
St. Louis	52.48	.24	.432	1.728	3.96	85.00	170.00	.75*j*	1.80*k*	65.1	57.1	62.0	53.5
San Francisco	55.00	.3275*d*	.5895*d*	2.358	5.895	107.25	178.75	.54	2.50	57.6	49.2	54.8	46.0
Seattle	55.35	.35	.63	2.52	6.30	72.00	175.00	.35*f*	1.30*f*	.....	.....	.....	....

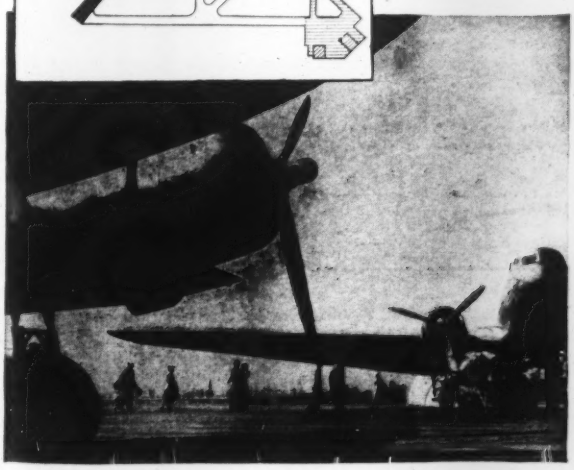
‡ Delivered. † F.o.b. *a* B. & S. class B and heavier, C/L lots, 200 tons and over Burlington, N.J. (base) $49.00. Gas pipe and class A, $3 per ton additional, 4 in., $3 per ton additional, 30 in. and larger usually $2 per ton less. *b* Double strength. *c* List to dealer. *d* List. *e* 30-inch. *f* Less 5% for cash. *g* Culvert pipe. *h* Discounts from standard list consumers carload prices, except Pittsburgh prices are f.o.b. mill. Base price $200 per net ton. List prices per ft.: ¼ in., 8½c.; ⅜ in., 11½c.; 1 in., 17c.; 2 in., 37c.; 2½ in., 58½c.; 3 in., 76½c.; 4 in., $1.00; 6 in., $1.92. *i* Applies also at Lorain, Ohio, mills. Chicago delivered base is 2½ points less on butt, 1½ on lap. Freight is figured from Pittsburgh, Lorain, O., Chicago Dist. Billing is from point producing lowest ptice at destination. WROUGHT IRON PIPE: Base price and list prices per ft. same as wrought steel pipe. Discount for Pittsburgh base: Butt-weld—1 in. and 1¼ in. black 34, galv. 19; 1½ in. black 38, galv. 21½; 2 in. black 37½, galv. 21. Lapweld—2½ in. to 3½ in. black 31½, galv. 17½ in.; 4½ in. to 8 in. black, 32½ galv. 20. *j* Reinforced; spec. C 76-37. *k* Reinforced; spec. C 75-37.

Toledo Airport rebuilds with CONCRETE

Toledo Airport's new concrete runways include a NE-SW strip 150 ft. x 3,650 ft. and an east-west strip 100 ft. x 3,000 ft. Geo. N. Schoonmaker is city manager; J. H. Jewhurst, dir. of public service; C. L. Piper, commissioner of engineering; Wm. B. Schmuhl, district WPA manager

Black area in plan shown below shows 101,678 sq. yd. of concrete runways under construction when photo was taken and since completed. Shaded area indicates an additional 63,709 sq. yd. planned.





..... *to carry the big planes safely and economically*

Toledo Airport is saying goodbye to dangerous, bumpy landings and costly runway maintenance. For two main runways—above shown under reconstruction—are now completed with strong, safe, enduring *Concrete.* And additional concrete pavement is planned.

On scores of airports throughout America, "ready-for-anything" concrete is delivering dependable service, wet or dry, winter or summer. Concrete is skid-resistant, clean and free from flying particles. Its light color improves visibility by day or night. Its beam strength bridges subgrades weakened by wet weather. And it can be designed *economically* to carry the wheel loads imposed by even the heaviest planes.

Will *your* runways stand up? Specify concrete and be sure! Design data on request.

PORTLAND CEMENT ASSOCIATION

Dept. A1a-17, 33 W. Grand Ave., Chicago, Ill.

A national organization to improve and extend the uses of concrete ... through scientific research and engineering field work

LUMBER, TIMBER, PLYWOOD—PER M FT., B.M., CARLOAD LOTS F.O.B.

	SHORT LEAF YELLOW PINE AND DOUGLAS FIR — All S. L. Y. P. is No. 2 common or better and for No. 1 N. C. Box. (Prices in Bold Face)									LONG LEAF Y. P. Merchantable grade up to 20 ft.		PLYWOOD* Rail freight increment (See note for base price)	
	All Fir planks No. 2 common: Fir timber is No. 1 common. Lengths up to 20 ft. (Prices in italics)												
	1x6 S4S	1x8 S4S	2x4 S4S	2x6 S4S	2x8 S4S	2x10 S4S	3x12 R&K	6x12 R&K	12x12 R&K	2x12 R&K	12x12 R&K	5/16"	3/4"
Atlanta	**$32.00**	**$32.00**	**$27.00**	**$28.50**	**$28.50**	**$32.00**	**$34.50**	.....	.....	$47.00	$57.00	$17.75	$21.60
Baltimore	**37.00**	**38.50**	**38.00**	**39.00**	**39.00**	**40.00**	**52.00**	.....	.....	74.00	76.00	17.35*g*	21.15*g*
	39.00	*39.00*	*41.00*	*40.00*	*40.00*	*40.00*	*52.00*	*$52.00*	*$52.00*	.....	.....	.....	.....
Birmingham	**34.00**	**34.00**	**31.00**	**31.00**	**31.50**	**32.00**	**42.00**	**42.00**	**51.00**	.....	.....	16.25	19.85
[1]	38.00	38.00	35.00	35.00	36.00	38.00	58.00	.....	.....	55.00	58.00	.....	.....
Boston	40.00[2]	40.00[2]	40.00[2]	40.00	60.00[1]	65.00[1]	77.00[1]	.....	.....	77.00	77.00	17.35*g*	21.15*g*
	38.00	*38.00*	*40.00*	*40.00*	*40.00*	*43.00*	*45.00*	*45.00*	*60.00*	.....	.....	.....	.....
Chicago	**42.00**	**42.00**	**38.00**	**38.00**	**38.00**	**43.00**	**52.00**	.....	.....	90.00	100.00	13.80	16.80
	40.00	*40.00*	*40.00*	*40.00*	*40.00*	*42.00*	*45.00*	*45.00*	*45.00*	.....	.....	.....	.....
Cincinnati	**37.50**	**39.00**	**35.00**	**35.00**	**36.00**	**41.00**	**50.00**	.....	.....	60.00	63.00	16.25	19.85
	.....	.....	.....	.....	.....	.....	*52.00*	*52.00*	*52.00*	.....	.....	.....	.....
Cleveland	**40.00**	**41.00**	**41.00**	**39.00**	**38.00**	**43.00**	**50.00**	50.00	50.00	83.00	83.00	16.70	20.40
Dallas *e*	**38.00**	**39.00**	**38.00**	**36.00**	**37.00**	**38.50**	**52.50**	**52.50**	**52.50**	76.00	81.00	13.90	16.95
Denver ‡	48.00[4]	46.00[4]	50.00[4]	49.00[4]	49.00[4]	51.00[4]	52.00[4]	64.00[4]	69.00[4]	.....	.....	9.90	12.05
Detroit	**42.00**	**42.00**	**40.00**	**42.00**	**42.00**	**44.00**	**51.00**	.....	.....	50.00	59.00	16.25	19.85
	.....	.....	.....	.....	.....	*49.00*	*58.00*	*59.00*	*59.00*	.....	.....	.....	.....
Kansas City	**42.50**	**42.50**	**40.00**	**40.00**	**40.00**	**42.50**	**42.00**	.....	.....	65.00	70.00	12.25	14.95
	42.50	*42.50*	*40.00*	*40.00*	*40.00*	*42.50*	*42.00*	*45.00*	*45.00*	.....	.....	.....	.....
Los Angeles *a*	*40.00*	*40.00*	*39.00*	*39.00*	*36.00*	*36.00*	*43.00*	*43.00*	*43.00*	.....	.....	9.35*gh*	11.35*gh*
Minneapolis ‡*b*	40.00[3]	40.00[3]	.....	.....	.....	.....	.....	.....	.....	.....	.....	12.05	14.70
‡	*42.00*	*42.00*	*42.00*	*40.00*	*40.00*	*42.00*	*44.50*	*53.50*	*53.50*	.....	.....	.....	.....
Montreal [7]	*36.00*	*38.00*	*36.00*	*38.00*	*40.00*	46.00	.....	.....	.....	155.00	165.00	.....	.....
	53.50	*53.50*	*54.25*	*54.25*	*59.25*	*59.25*	*65.00*	*65.00*	*65.00*	.....	.....	.....	.....
New Orleans	**24.00**	**25.00**	**25.00**	**24.00**	**24.00**	**25.00**	**46.00**	.....	.....	62.00	69.00	13.90	16.95
	29.00	*29.00*	*32.00*	*33.00*	*35.00*	*34.00*	*36.00*	.....	.....	.....	.....	.....	.....
New York ‡	**48.00**	**49.00**	**43.00**	**45.00**	**45.00**	**46.00**	**48.00**	.....	.....	82.50*f*	85.00*f*	17.35*g*	21.15*g*
‡	.....	.....	*50.00*	*50.00*	*50.00*	*50.00*	*50.00*	*52.50*	*52.50*	.....	.....	.....	.....
Philadelphia	**24.00**	**24.50**	**25.50**	**25.50**	**27.50**	**27.50**	**29.00**	.....	.....	50.00	57.50	17.35*g*	.151*2g*
	35.00	*36.50*	*39.00*	*38.25*	*39.00*	*39.00*	*44.00*	*52.00*	*52.00*	.....	.....	.....	.....
Pittsburgh	**50.80**	**53.20**	**62.75**	**55.00**	**60.85**	**62.50**	**76.25**	.....	.....	.....	.....	17.00	20.70
	69.20	*68.10*	*66.10*	*65.30*	*65.20*	*65.65*	*88.75*	*88.75*	*88.75*	.....	.....	.....	.....
St. Louis ‡*c*	**42.00**	**42.00**	**38.00**	**37.00**	**38.00**	**39.00**	**50.00**	*58.00*	*58.00*	76.00	75.00	13.90	16.95
San Francisco *d*	*28.00*	*27.00*	*28.00*	*29.50*	*29.00*	*29.50*	*29.50*	*28.00*	*28.00*	.....	.....	7.30*g*	8.90*g*
Seattle	*27.00*	*27.00*	*27.00*	*27.00*	*27.00*	*27.00*	*36.00*	*36.00*	*36.00*	.....	.....	0.00	0.00

Bold Face type, Southern Pine. *Italics, Douglas Fir.* [1] Long leaf. [2] Roofers' N. C. Pine. [3] Spruce. [4] Native. [5] Western Pine, No. 3 Common. [7] Spruce. [8] Norway Pine. ‡ Delivered. *a* Yard prices. *b* Contractors discount in Minneapolis and St. Paul discontinued May 21, 1938. *c* 5M ft. or less. *d* At ship's tackle. *e* 10% discount taken off. *f* Up to 18 ft.

NOTE: Special concrete form grade Fir Plywood, 4' by 8' panels, 5-ply, sanded 2 sides, water resistant glue, carload lots, delivered per 1,000 sq. ft. surface. Seattle base price on 5/16", $81.60; on 3/4", $89.90; price includes oiling and sealing charges. For other centers add rail freight increment from table or proper size. For resin dipped treatment, add $10.50 per M. *Many mills out of market due to rush of defense orders. *g* Lower rate by water shipment. *h* 50,000 lb. minimum

GLASS, EXPLOSIVES, CHEMICALS

	WINDOW GLASS — Discounts from jobbers list, Aug. 15, 1938 Single or Double Thickness		EXPLOSIVES — Per lb. 40% Ammonia Gelatin in 50-lb. cases delivered in 200 lb. lots*	
	A quality	B quality		
Atlanta	75%	75%	$0.15	
Baltimore	82%	81%	.15	
Birmingham	75%	75%	.105	
Boston	80%	81%	.15	
Chicago	79%	79%	.15	
Cincinnati	77%	77%	.15	
Cleveland	79–10–10%	79–10–10%	.19	
Dallas	78%	78%	.1625	
Denver	77%	77%	.155*e*	
Detroit	79–10%	79–10%	.15	
Kansas City	77–10%	77–10%	.155	
Los Angeles	86%*d*	88%*d*	.1575	
Minneapolis	76%	76%	.155	
Montreal	40–10%	50–5%	.155†	
New Orleans	70%	75%	.16	
New York	81%	82%	.22*f*	
Philadelphia	82–10%*d*	83–10%*d*	.15	
Pittsburgh	79%	79%	.1225	
St. Louis	77–10%	77–10%	.155	
San Francisco	78%*d*	83%*d*	.155	
Seattle	85%*d*	88%*d*	.1575†	

Price of 60% Ammonia Gelatin is $0.015 per lb. higher than 40%

a Disc. from list Sept. 1939. *b* Also less 6% tax exemption. *d* Discount from jobbers' list Sept. 15, 1928.

* Urban prices influenced by service charges or local storage and delivery regulations, do not consistently reflect quantity prices in less congested areas. *e* F.o.b. Louviers, Colo. *f* In boroughs of Kings, Queens and Richmond, and in Manhattan south of Canal Street, add delivery charge of $6.00 per trip. † F.o.b.

40% Ammonia Gelatin price ranges in other than urban areas, per lb. (except Seismograph Grades)

	C/L 20,000 lb. net	Tons	200 lb. lots
E. of the Miss., except Fla	$0.105	$0.14	$0.16
W. of Miss. to Rocky Mtn. States, and Fla	.11 –.1175	.135 –.1475	.155 –.1675
Rocky Mtn. States	.105 –.1325	.125 –.1375‡	.135–.1525‡
Pacific N. W. States	.1075–.12	.1375–.15	.1575–.17
Pacific S. W. States	.1050–.1175	.135 –.1475	.155 –.1625

‡F.o.b. Louviers, Colo., or Butte, Mont.

PILES, TIES—F.O.B.

PILES

Prices per linear foot, pine, with bark on, f.o.b. New York; delivered from barge 1½ to 2c. per ft. additional:

Dimensions	Points	Length	Short Leaf — Barge	Short Leaf — Rail
12 in. at butt	6 in.	30 to 50 ft.	$0.18	$0.195
12 in.— 2 ft. from butt	6 in.	50 to 59 ft.	.225	.24
12 in.— 2 ft. from butt	6 in.	60 to 69 ft.	.23	.255
14 in.— 2 ft. from butt	6 in.	50 to 69 ft.	.24	.265
14 in.— 2 ft. from butt	6 in.	70 to 79 ft.	.28	.275
14 in.— 2 ft. from butt	5 in.	80 to 85 ft.	.40	.415
14 in.— 2 ft. from butt	5 in.	85 to 89 ft.	.42	.482

RAILWAY TIES

Prices f.o.b., per tie for carload lots:		6"x8"x8' Untr.	6"x8"x8' Tr.	7"x9"x8'6" Untr.	7"x9"x8'6" Tr.
Boston	Oak	$1.20	....	$1.65	.....
	Pine	1.50	$2.25*a*	2.25	$3.20*a*
New York	S. L. Sap Pine	1.20/1.30	1.95	1.60	2.45
	Mixed Oak	1.55	2.05	2.00	2.55
Birmingham	White Oak	.85	1.50*a*	1.35	1.70*a*
	Southern Pine	.55*b*	1.10*ab*	.70	1.30*a*
Chicago	Oak	....	1.65*a*	....	2.25*a*
	Southern Pine	....	1.53*a*	....	2.13*a*
Los Angeles	Douglas Fir	.64	1.38*a*	.90	1.80*a*
Philadelphia	Red Oak	1.10	....	....	2.40*a*
St. Louis	White Oak	1.12	....	1.50	....
	Red Oak	1.12	1.60*a*	1.50	2.05*a*
	Sap Pine or Cypress	1.02	....	1.40	....
San Francisco	Douglas Fir	1.00*bef*	....	....	2.45*caf*
Montreal	Birch or Maple	.65	1.05*a*	.75	1.35*a*

Tr.— Treated; Untr.— Untreated. *a* Creosoted. *b* 6" x 8" x 8'6". *c* Empty cell. *d* Zinc. *e* Green. *f* At ships tackle.

CHEMICALS

Water, sewage treatment, road work, f.o.b. carlots, New York

Bleaching powder, in drums, f.o.b. works, per 100-lb	$2.00–2.85
Chlorine cylinders, liquid, per lb. delivered	.0525
Calcium chloride, 77–80%, flaked, in 400-lb. drums or 100-lb. moisture proof bags, delivered, per ton	20.50–35.00
Silicate of soda, 52 deg., in drums, f.o.b. works, per 100 lb	1.40
Soda ash, 58%, in paper bags, per 100 lb. dense	1.10
Sulphate of aluminum, commercial, in 100-lb. bags, per ton	23.00
Sulphate of copper, in bbl., per 100-lb	4.75

DUNKED IN [illegible] FOR LONG[illegible]

Purple Strand Wire Rope

This length of hemp rope is about to become the center of a piece of Bethlehem Purple Strand wire rope. Every fibre of this hemp rope has been impregnated with a compound that both lubricates and preserves.

Now, as a further protection, the hemp core plunges into a vat of hot lubricant, emerges with a thick, smooth coating and is pulled, together with the strands, into the closing die. Here the strands close around it. The hot lubricant is squeezed uniformly into every nook and cranny, and the rope is ready for shipment.

When you consider that the strands in Bethlehem wire rope are themselves bathed with a lubricant which is basically matched to the core lubrication, you see how thoroughly Bethlehem handles this important problem.

Why not try Bethlehem Purple Strand on your own job? It's made of premium Improved Plow Steel, is manufactured on new machinery; its individual parts fit together with accurate precision. The performance record of this fine rope is its best salesman.

BETHLEHEM STEEL

BETHLEHEM STEEL COMPANY

STRUCTURAL CLAY BUILDING TILE, BRICK AND LIME—DELIVERED

	STRUCTURAL CLAY TILE — PARTITION — SCORED Per M. lots of 2,000 pieces or over,			STRUCTURAL CLAY TILE — LOAD BEARING — SCORED Per M. lots of 2,000 pieces or over,			BRICK Per M. in quantity.		LIME		
	3x12x12 in.	4x12x12 in.	8x12x12 in.	8x12x12 in.	10x12x12 in.	12x12x12 in.	Common backing	Straight hard	Per ton, Hydrated finishing	In paper, Common hydrated	Carload lots, Pulverized or lump
Atlanta	$90.00	$100.00	$185.00	$220.00	$230.00	$240.00	$12.50	$16.00	$26.50	$17.00	$17.00
Baltimore	75.00	80.00	150.00	180.00	225.00	280.00	14.00*k*	17.00*k*	18.50	15.00	2.50*n*
Birmingham	80.00	85.00	160.00	191.00	252.00	288.00	13.50	16.50	18.11	12.64	1.66*n*
Boston	82.10*a*	87.60*a*	164.20*a*	186.10	243.20*a*	277.90*a*	17.00*i*	20.00*i*	17.50	12.91	16.50*i*
Chicago	68.10	72.60	135.90	185.70	234.90	268.10	11.00	12.00	16.40	14.40	12.20
Cincinnati	61.40	65.30	121.90	141.50	187.30	215.20	16.00	16.00	15.90	13.00	.....
Cleveland	56.50	60.00	112.50	135.00	182.00	209.00	16.00	16.00	19.00*j*	15.00*j*	2.75*n*
Dallas	62.50	67.00	135.00	162.00	177.00	263.00	11.50*i*	13.50*i*	19.00	15.00	.95*n*
Denver	84.80	94.40	152.70	178.20	212.00	227.90	13.50	17.00	30.00*j*	19.00*j*	30.00*j*
Detroit	69.00	73.60	138.00	176.00	232.00	265.00*e*	16.00	17.00	16.00	13.75	14.75
Kansas City	64.50	66.50	86.00*c*	125.50	159.75	186.25	14.25	24.00	19.10	12.80	10.70
Los Angeles	73.50†*r*	89.50†*r*	128.00†*r*	210.00†*r*	368.00†*r*	460.00†*r*	13.50	15.00	16.50	.....	17.50
Minneapolis	71.45	76.20	143.95	171.45	173.80	242.10	13.10	15.10*g*	21.00	16.00	19.00
Montreal	72.20*a*	77.50*a*	142.50*a*	76.00*at*	165.80*a*	248.70	17.50†	24.25†	23.50	17.00	12.00
New Orleans	72.00	72.00	135.00	162.00	210.00	260.00	14.00	.....	18.30	12.08	14.10
New York	87.00	93.00	128.00*c*	193.30*h*	238.80*h*	295.60*h*	13.00	.....	19.00	14.00	17.00
Philadelphia	80.50	85.90	161.10	193.30	238.80	295.60	15.50*s*	18.00*s*	15.50*l*	9.55*q*	12.05*q*
Pittsburgh	58.40	62.40	116.85	124.00	153.00	193.75	17.00	25.00	17.90	15.40	2.55*m*
St. Louis	62.00	88.00	120.00	180.00	234.00	280.00	16.00	17.00	22.00	16.00	2.30*m*
San Francisco	84.00	94.50	225.00	.....	.....	.....	14.00	17.00	.55*o*	.40*p*	2.05*m*
Seattle	100.00	110.00	220.00	.....	.....	.....	17.50*f*	17.50*f*	20.00*s*	20.00*s*	20.00*s*

† F.o.b. *a* Smooth. *b* Carload lots delivered to job. *c* 6x12x12 in. *d* Not load bearing. *e* 48 lb. tile. *f* Less $1.00, ½ cash 15 days, balance 30 days. *g* Selected common. *h* F.o.b. Perth Amboy, N. J. *i* 50c. per M. off for cash. *j* LCL. *k* $1.00 discount if paid in 10 days. *l* Lump. *m* Per bbl., 180 lb. *n* Per sack 100 lb. *o* Per bbl., 200 lb. *p* 280 lb. bag. *q* 25-ton cars. *r* 5% discount 10 days. *s* 2% off cash. *t* 5½ x 8 x 12.

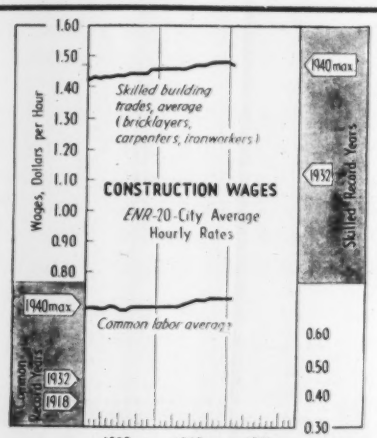
PAINT, ROOFING—F.O.B. CARLOAD LOTS

	RED LEAD Per 100 lb. in 600-lb. (Approx.) bbl. Dry *a*	WHITE LEAD Per 100 lb. in oil	READY-MIXED PAINT Per gal., drums Graphite *b*	Aluminum *c*	Ferric Oxide *d*	ROOFING SUPPLIES Carload lots f.o.b. factory Rolls, slate surfaced, 85-90 lb. per sq.	Asphalt felt, per 100 lb.	Tar felt, per 100 lb.	Asphalt coating per gal.	Tar pitch 350 lb. bbl. per ton
Atlanta	$9.50	$13.125	$1.30	$2.25	$1.20	$1.90	$1.61	$1.61	$0.27	$29.00
Baltimore	9.25	12.75	1.75	2.50	2.00	2.50	3.00	3.00	.60	29.00
Birmingham	9.50	13.125	2.35	2.75	1.85	1.98	1.57	1.57	.32	27.00
Boston	9.25	12.75	1.85‡	2.50‡	1.80‡	1.96‡	1.85*h*‡	1.85*h*‡	.50‡	20.00‡
Chicago	9.25	12.75	1.96	2.03	1.68	1.45*hf*	1.50*hf*	1.50*hf*	.26*f*	22.00*f*
Cincinnati	9.25	12.75	1.65	2.85	1.55	2.40	2.39*h*	2.39*h*	.36	21.00
Cleveland	9.25	12.75	1.90	2.60	1.60	1.75	1.50*h*	1.50*h*	.35	21.00
Dallas	9.25	13.50	1.88	2.11	....	2.50*h*	2.60*h*	2.70*h*	.50	31.00
Denver	9.75	13.25	1.65	2.40	.17*i*	2.45	4.00	3.00	.35	28.00
Detroit	9.25	12.75	1.75	2.75	1.25	2.40	2.50	2.50	.35	26.00
Kansas City	9.25	12.875	2.15*g*	2.40*g*	1.67*g*	1.93	2.09	2.09	.25	25.00
Los Angeles	9.50	13.25	1.60	2.25	2.30	2.10	1.50	....	.45	.....
Minneapolis	9.25	12.875	....	....	....	1.75*i*	1.50*hi*	1.50*hi*	.29	21.00
Montreal	9.25	9.00	2.40	2.97	2.51	2.64	1.85	1.86	.63	1.85*h*
New York	9.25	12.75	1.88	2.55	1.60	1.75	1.50*h*	1.50*h*	.23	24.00
Philadelphia	9.25	12.75	....	....	....	1.92*e*	1.99*he*	1.99*he*	.41*e*	21.00
Pittsburgh	9.25	12.75	1.05	1.95	.80	1.95	1.94*h*	1.94*h*	.34	26.00
St. Louis	9.25	12.75	1.90/2.00	2.60/2.80	1.60/2.00	2.04	1.50	1.50	.24	22.00
San Francisco	9.50	13.00	1.80	2.75	1.10/2.00	1.65	2.26	2.26	.28	17.00
Seattle	9.50	13.25	1.80	2.60	....	1.81	1.30/2.00	1.75	.35	28.00*j*

‡ Delivered. Note: Red lead in oil 50c. higher than white lead in oil *a* Red lead prices change frequently due to pig lead price changes. *b* U. S. War Dept. Spec. 3-49A. *c* ASTM Spec. D266-31. *d* 80% minimum ferric oxide. *e* Subject to 25% discount. *f* Distributors' price to contractors. *g* 5 gal. can. *h* Per roll, 65 lb. *i* Minneapolis and vicinity. *j* Asphalt pitch. *k* Per 100 lb. *l* Per lb.

SKILLED AND COMMON WAGE RATES—PER HOUR

	Bricklayers	Carpenters	Struct. Iron Workers	Hoisting Engineers	Plasterers	Common Labor Building	Common Labor Heavy Const.
Atlanta	$1.25	$1.00	$1.375	$1.00/1.25	$1.25	$0.40/.50	$0.40/.50
Baltimore	1.50	1.25	1.65	1.50	1.375	.625	.625
Birmingham	1.50	1.125	1.375	1.125	1.00	.40	.40
Boston	1.50	1.00/1.25	1.50	1.625	1.625	.60/.85	.60/.85
Chicago	1.70	1.625	1.70	1.70	1.70	1.025	1.025
Cincinnati	1.625	1.45	1.55	1.375/1.525	1.625	.75	.75
Cleveland	1.625	1.375	1.50	1.50/1.75	1.625	.90	.90
Dallas	1.50	1.00	1.25	1.00	1.50	.40/.50	.40/.50
Denver	1.65*b*	1.43*b*	1.43*b*	1.43*b*	1.50*b*	.718*b*	.718*b*
Detroit	1.50	1.25	1.625	1.50	1.55	.60/.75	.60/.775
Kansas City	1.625	1.375	1.50	1.50	1.575	.85	.50
Los Angeles	1.25	1.10	1.375	1.375	1.50	.625	.625
Minneapolis	1.375	1.25*d*	1.50	1.40	1.50*e*	.85	.85
New Orleans	1.50	1.25	1.375	1.375	1.40	.40	.50
New York	2.00*b*	1.85*b*	2.00	2.00*b*	2.00*c*	1.031	.875/.95
Philadelphia	1.65*b*	1.40	1.65	1.50	1.75	.70	.70
Pittsburgh	1.75	1.50	1.50	1.25	1.75	.80	.70
St. Louis	1.50	1.00/1.50	1.75	1.50/2.00	1.75	.45/.875	.875
San Francisco	1.75*c*	1.25	1.60	1.50	1.60*c*	.813	.813
Seattle	1.60	1.25	1.50	1.50	1.60	.90	.90
Montreal	.80	.70	.75	.65	.80	.45	.40



b 7 hr. day. *c* 6 hr. day *d* 35 hr. wk. *e* 30 hr. wk.

ENR Skilled Average: (Bricklayers, Carpenters, Ironworkers) **$1.469**
ENR Common Average: $0.711